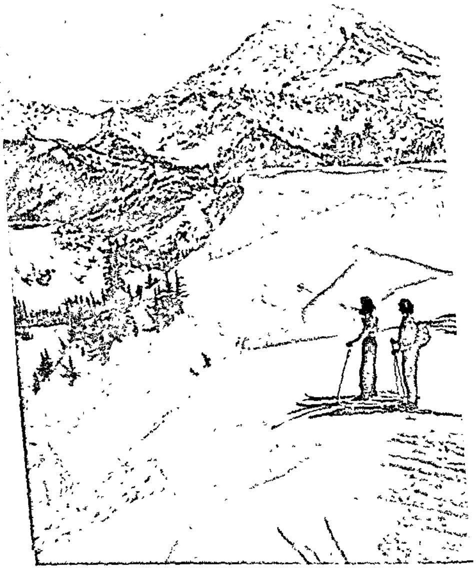
Our Environment

How We *Adapt* Ourselves to It



Health and Happiness.—*Outdoor* exercise makes us happy and healthy. Science tells us why and shows us *how* to use our environment for achieving good health.

ADVENTURES IN SCIENCE

CARPENTER & WOOD'S OUR ENVIRONMENT

How We ADAPT Ourselves to It

REVISED BY

Paul E. Smith

DIRECTOR OF CURRICULUM
ROCHESTER, NEW YORK

1955

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HARRY A CARPENTER (1878-1942) was one of our nation's outstanding pioneers in the teaching of general science His work in Rochester, New York, with children at all levels of the curriculum, in the classroom, out in the field, and over the air, gave new significance and purpose to the teaching of science He made science a subject of living interest to thousands of school children everywhere

By reason of his kindly spirit and genial leadership, Mr Carpenter had a way of bringing into his work young people who could see the far horizon Mr Paul E Smith in particular worked very closely with Mr Carpenter. As a former student and teaching colleague, Mr Smith learned at first hand the method of science instruction so successfully presented in this series of books To him was entrusted the task of carrying on the work so well begun by Mr Carpenter Thus teachers who know and depend on these books have the assurance that the good work will continue.

PRINTED IN THE UNITED STATES OF AMERICA

Preface

This new edition of OUR ENVIRONMENT: HOW WE ADAPT OURSELVES TO IT features the latest developments in the field of science. The new format, larger pictures, simplified diagrams, clear typography, and readable text high-light the up-to-date quality of this revision.

Along with its many new features, teachers will recognize the time-proven pattern of basic content which has made this book and its companion volumes so popular in their field. There is the same soundness of unit structure built around everyday factors of the environment, the same cumulative development from topic to topic, and the same simple emphasis of scientific attitude and method which makes science practical and real to the pupil.

Readability is a special feature of this book. Special attention has been given to the reading level to insure easy readability for the grade concerned. New science terms which have become commonplace within the past few years have been introduced and fully explained to insure accuracy of meaning concepts. Sentence structure and paragraph structure are very simple and every advantage has been taken of visual materials, pictures, and diagrams to aid in understanding.

Today's pupils are increasingly concerned with the everyday applications of practical science. This interest is turned to good account in this book's new unit, "Magnets and Electricity." This unit contains simplified but scientific explanations of the electric motor, the generator, radar, teletype, radio, and television. Its new experiments provide for the development of related principles, and its discussion of atomic energy is at a level which girls and boys of junior high school age can understand. Thought is directed toward the peacetime use of this source of energy.

Unit IV, "Community and Personal Health," another new unit, focuses the interest of the pupil on the uses of water as an aid to health. This unit includes also such recent developments as sulfa drugs, antibiotics, ACTH, and cortisone. Throughout the unit emphasis is placed on the pupil's responsibility for his own health and the health of his community

Wherever context indicates, the latest related findings of science are introduced. These new items of interest cover a wide range of development and discovery featuring topics like the Hale and Schmidt telescopes, most recently discovered star distances, a new theory of the origin of the earth, and up-to-date information on air masses, rain-making, hurricane-chasing, detergents, incinerators and sink disposal units for food wastes, dehumidifiers, weed killers, garden dusts and spray formulas, conservation, burning of unmined coal underground, and taconite as a new source of iron

The method of teaching science determines to a large extent the success in attaining desired outcomes. OUR ENVIRONMENT: HOW WE ADAPT OURSELVES TO IT has been built upon certain foundations with respect to the teaching of science to pupils of junior high school age. These foundations are:

1 Science education at this level must be for the purpose of general education, and not for the training of specialists in science.

2. The most significant outcome of the teaching of science is the development of scientific attitudes and increased competence in the method of science.

3 Scientific knowledges and skills are most valuable when the pupil is led to organize the knowledges and skills into scientific principles or generalizations which may be applied to new problem situations.

4. Facts of science are indispensable to the formulation of science principles. Knowledge and organization of relevant and pertinent facts are essential to an understanding of the environment in this Age of Science.

The text as heretofore is divided into *Units*, each unit presenting a unified picture of some phase of the student's environment. Each unit is composed of a series of *Topics*, developed in logical order, an understanding of which comprises a complete grasp of the larger unit division.

Problem-solving abilities are cultivated by the *General Problems* which comprise a psychological development of each topic. Each general problem may include a number of *Experiments* (laboratory work) or *Field Research* problems for independent choice and individual or group solving.

The problem method involves both a realization of the problem on the part of the student and a foundation on which to base his solution. To these ends the student's everyday experiences must be reinforced by carefully directed observation in the classroom and by out-of-school experiences designed to crystallize the habits of careful, accurate observation and judgment. For this reason, an *Observers' Club Calendar* is included in the Appendix as a stimulus to initiative and independence in the use of the scientific method.

Characterizing the presentation of each unit are the following features:

1. The material of each unit is developed as a number of related topics. The general problems of each topic lead toward minor generalizations that provide a framework for the building up and fitting in of the principles that are discovered, observed, and learned for the unit as a whole.

2. Each *Topic* is introduced by an informational picture. This feature, together with the *Do You Know* questions, relates present experiences and knowledge to new problems.

3. Within each topic will be found *Field Research* problems and Science Discovery Book *Projects*. These offer an opportunity for taking care of individual differences and are closely allied to the extra-class activities of the *Observers' Club Calendar*.

4. *Key Words* are found at the end of each topic. They are valuable both for preview and review work. As an oral exercise, their exact meaning may be brought out in short sentences or paragraphs, thus supplying drill in the formation of general concepts.

5. A group of *Key Statements* follows the key words in each topic. These sentences are summarizing statements, and may be used for topical, oral, and written exercises to provide training in the use of careful, exact expression.

6. A series of *Thought Questions* at the end of each topic tests the ability of the pupil to apply his science to new situations.

7. The *Bibliography* has been selected with special regard for the interests of the pupils using this book.

8 The *Glossary* provides simple understandable definitions of the key words and other science terms

9 *Experiments* are numerous. The fundamental experiments are labeled *Key Experiments*, because they are especially important in the organization of the subject matter. They pin-point facts for discussion and encourage the scientific attitude of mind They should be used as individual student experiments or at least should be demonstrated to the class by pupils Since some classes may find it impossible to perform all of the experiments, the text has been made completely coherent without dependence upon the experiments in any way.

10. Illustrations have been selected in the belief that every picture and diagram should increase interest in science, amplify and interpret the text, present a problem for study, and be easy to understand. Every picture carries an explanation and often questions requiring close study of the picture and direct association of it with its context

This preface would not be complete without expressing appreciation to the thousands of teachers and hundreds of thousands of boys and girls who have used previous editions of this text Their letters, comments, suggestions, and experiences have played a significant part in the development of this new edition This eagerness to exchange ideas is a hallmark of the true scientist and hence doubly gratifying to author and publisher, because it shows the growth in scientific attitude and thought which is the basic aim of this book.

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Unit II. THE HEAVENS

Unit V. FARM AND GARDEN

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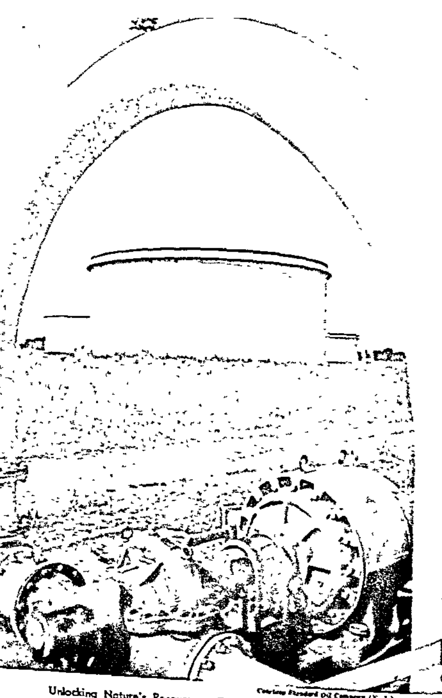
EXPERIMENTS



Courtesy Standard Oil Company (N. J.)

Unlocking Nature's Resources.—The field pump, pipe lines, and storage tanks bring to mind one of our most valuable natural resources—oil. Many scientists are working to discover wise methods of using our resources so that there will be enough for future generations. There is no room for waste in using our resources.

Introduction

Have you ever thought how important science is in your life? Have you ever thought how fast science moves ahead? There was a time when the electric light bulb was considered a "wonder of the age." But you know that giving light is just one of the hundreds of modern uses of electricity. Other uses are electric motors, telephone, radio, television, radar.

While many scientists work with electricity, others are studying the sun and the planets. Some are using the 200-inch Hale telescope to study the vast space out beyond our solar system.

Weather scientists are recording the weather factors, such as air temperature, winds, and moisture. Their weather forecasts are becoming more and more accurate. Some scientists are even experimenting at making weather. It has been discovered that some clouds can be made to give up their moisture in the form of rain. It has also been discovered that clouds can be made—clouds that hold on to their moisture and prevent rain from falling.

Still other scientists are working to keep our communities sanitary and our own lives healthy. They have discovered ways to give us safe water and milk. They have discovered ways to help us fight diseases. They have given us soap for cleaning, which is so important to health. They have given us sulfa drugs, penicillin, ACTH, cortisone, vaccines, and serum. But with all these scientific defenses against disease, scientists still tell us that health is something each of us must work for. So scientists have told us the best kind of health habits to form.

Many more scientists are working with the soil, crops, insects, and plant diseases. The scientists tell us what kind of crops the soil can best support. They tell us how to plant the crops and take care of them. They study plant diseases and make chemicals which will prevent the diseases. They learn about the habits of insects which eat the crops, and make poisons which will control the insects.

Equally important are the scientists who study our natural resources. They explore to find new deposits of vital materials. They experiment to find better ways of gathering our natural resources and using them. They study new ways to prevent waste. And they tell us that conservation is everyone's job.

There is little in our lives which is not affected by science. But do you know how scientists work to make their discoveries? If you can work and think like a scientist, you will be able to do your own job better, no matter what it is.

Working Scientifically.—The scientific attack starts with a problem the scientist wants to solve. He learns what he can about the problem from the reports of others. Next he puts down what he has discovered and then tries to learn some new facts.

New facts are usually learned by trying experiments. Sometimes experiments are tried over and over again to see if the same results are always obtained. A place where experiments are tried is often called a *laboratory*. It has apparatus and materials for experiments and often some reference books.

Experimenting requires good judgment and straight thinking. First, one must try to avoid dangerous experiments. Next the experimenter must watch very carefully to see just what happens. And he must think hard to figure exactly why it happens.

Of course a good scientist keeps a notebook record of what he does, how he does it, and what he discovers. Most records are helped by drawings. His next step is to look over all he now knows about the problem, organize his material, and try to get an answer. This he writes down as a temporary conclusion or theory. A scientist tries to learn the truth whether it agrees with what he would like to know or not.

The temporary conclusion or theory must be double-checked by other scientists as well as by himself before it is accepted. Even then the experimenter is ready to change his opinion if new facts are discovered that challenge his statement. This is the way scientists work. It is the way you will want to work, not only in science, but in all the things you do.

Our Environment

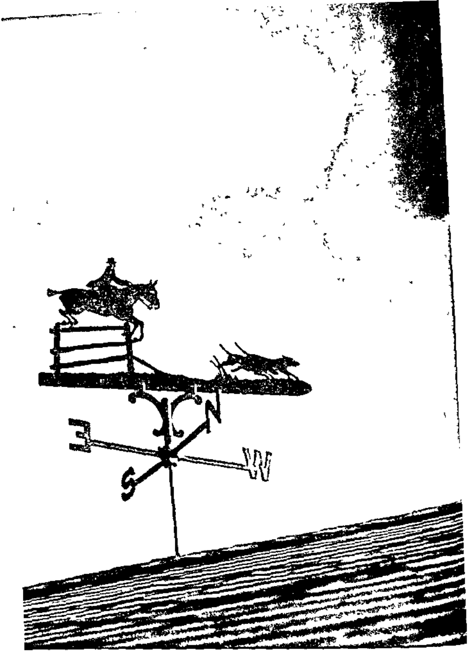
How We Adapt Ourselves to It

Frank Spiecker

A Real Twister—We don't know if man will ever control the weather to any extent. However, our scientists learn more about weather every day, and their forecasts warn us of coming danger, like this tornado.

UNIT I

Weather



A Silent Weatherman.—The direction of the wind has always been important as an aid in forecasting the weather. Some weather vanes are very plain, others, as this one, are artistic. Can you tell which part of this weather vane is stationary? Can you tell which part is moved by the wind?

TOPIC I

Weather Signs and Superstitions

DO YOU KNOW—

1. How weather sayings started?
2. A weather sign that seems to be true?
3. Whether the moon controls the weather?
4. Whether animals can tell whether the winter will be unusually cold?
5. Some of the common clouds?

GENERAL PROBLEM 1

Are Weather Superstitions Based on Evidence?

HOW WEATHER SUPERSTITIONS STARTED.—From earliest days, man has been interested in the weather. The food supply, in all parts of the world, has always depended on the weather. Would the rains come in time to save the crops? Would the rains stop in time to allow the crops to be planted? These are questions farmers have always thought about and worried about.

Sometimes we think that modern people are not so dependent upon the weather. But is this so? Long periods without rain still mean less wheat from the fields. Too much rain will harm the corn crop. Unusually heavy snows on the cattle ranges will cause many cattle to die from lack of food. In the winter of 1949–1950, many of the western states were blanketed with a heavy snowfall. Only "Operation Haylift" saved the cattle.

A Good Weatherman?—Some people think that the robin has a rain song which tells of a coming storm. Would you trust his judgment?

In Operation Haylift, huge Air Force transport planes flew in tons of hay for the starving cattle.

Because people have always been interested in the weather, they have tried to tell what the weather would be They have watched for signs which would tell them something about the weather Sometimes they have tried to foretell the weather by observing animals. Sometimes they have thought the shape or position of the moon would tell them about the weather. Sometimes they have used clouds, or wind, or rainbows as weather signs. Are these useful weather signs? Or are they just superstitions?

FORETELLING WEATHER BY ANIMALS.—Do animals with heavy fur in the fall indicate a cold winter to come? Do heavy feathers on birds tell anything about the coming winter? Do geese flying south foretell oncoming winter? Do crickets tell the temperature? Does the groundhog's shadow on February 2 have anything to do with the weather? These and many other questions are not new to you. But unless you understand the science of weather, you cannot answer them correctly.

Careful observation and experiment have shown that the coat of fur on animals depends upon the food supply during the spring and summer. When there is plenty of food, the coat is usually heavy. When food is scarce, the coat may be thin. Actually the coat does not depend at all upon the animals' sense of coming changes in the weather.

It is true that animals of all kinds make preparations for changes of seasons. We know that they lay up food, or prepare a den. But animals do not know any more than you do whether the season is to be normal or otherwise. Certainly fur-bearing animals have heavier coats of fur during the winter than in the summer. This is part of nature's way of adapting them to the colder weather. Also, these animals shed a good deal of their fur in the summer. But these are normal preparations. They do not involve any "knowledge" of an unusual season.

FIELD RESEARCH

Make observations of your own on the preparations birds and animals make for the winter. Compare your report with others.

Winter's Coming.—This bear does not know that the weather will turn cold, but Nature does. How will she protect him?

Kabel

Ring around the Moon.—A ring around the moon often foretells rain or snow. What causes the ring to form? Why should the ring indicate a coming storm?

We know that geese and other migrating birds nest and raise their young in the north. They stay near their nests until their young are strong and able to fly long distances. By this time ponds and lakes usually begin freezing over. There is less and less food to be found, and the birds begin moving southward.

Some birds, like geese, cruise leisurely southward. They fly now in one direction and now another, searching for food on their journey. Some fly by night and feed by day. Others fly great distances without stopping until they reach their destination. No one really knows exactly why birds migrate, except that they follow the food supply. But certainly the migrations of birds do tell us of the changing seasons.

LIBRARY RESEARCH

Investigate the migration of birds to discover reasons for their movements other than that, as people say, "They know cold weather is coming."

The robin's rain song, the dry fog, and low-curling smoke are but a few of many weather signs. They come to us out of the nature-lore which generations of farmers, hunters, and other outdoor folk have built up. Our job is to learn to distinguish among those signs which are based on scientific sense and those that are not. Careful, long-range observations of nature and weather changes will disprove many weather superstitions. What we learn in our science experiments will also help us decide which signs are true, and which are superstitions. We will get the scientific knack of searching out the facts. We may also find fun in some of the foolish but still quite commonly accepted superstitions and misbeliefs.

THE MOON AND THE WEATHER.—There are many weather signs and superstitions relating to the moon. The weather does not depend upon the moon. Therefore, the moon cannot indicate the weather. Such sayings as, "When the crescent moon can hold water it will be dry," and, "Fish bite best as the moon grows full," are just not true.

Statements relating to the moon and weather probably result from observations of the moon during certain kinds of weather. However, if the observations are continued long enough, the study shows that the moon has no influence upon the weather. The motions and changes in shape of the moon occur and recur with clocklike precision. Do weather changes occur with that same regularity?

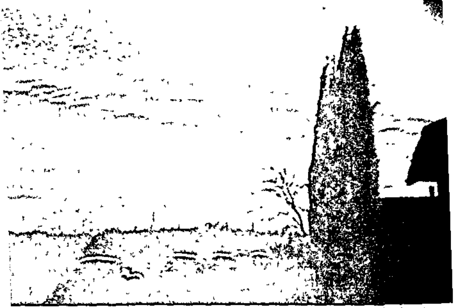
FIELD RESEARCH

Talk with your friends to learn as many sayings as possible about the moon and weather. Give your reasons for thinking the sayings have or have not any facts behind them.

GENERAL PROBLEM 2

Are There Scientific Weather Signs?

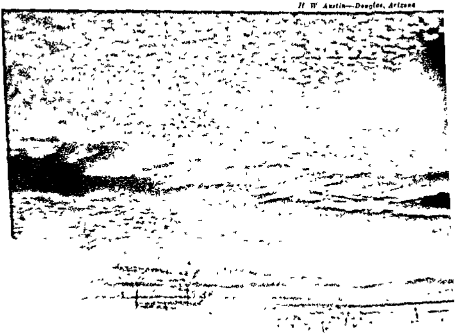
FACT AND FANCY.—Although many weather sayings are superstitions, some are accurate scientific statements. Some conditions that we observe can be used to help foretell the weather. In general, winds, humidity, clouds, and rainbows



H. W. Austin—Douglas, Arizona

Cloud Forms—These beautiful pictures show the sky with more than one cloud form appearing. In both pictures we can see stratus clouds near the bottom, cirrostratus in the middle, and altocumulus above. The picture below was taken about fifteen minutes after the other one.

H. W. Austin—Douglas, Arizona



often give some information about the coming weather. These are conditions of the air. Hence we might expect them to be more scientific than, for example, the amount of fur on an animal.

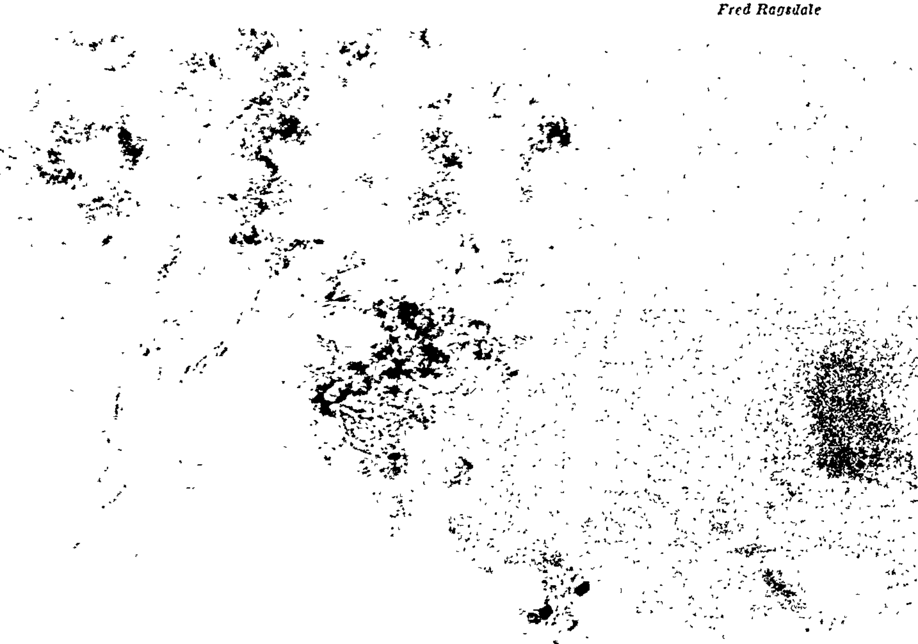
RINGS AND RAIN.—A ring around the moon may indicate the approach of a storm. The ring is caused by the action of light on ice crystals or water particles in the air. As the ice or moisture-laden air moves toward us, the ring often grows larger. Hence there is some truth in the old saying: "The bigger the ring, the nearer the storm."

We should remember that the moon is about 240,000 miles from the earth. The icy or watery clouds are only a few miles about the earth. Light from the moon shines on the ice particles causing the ring appearance.

Sometimes a large ring of color is observed about the sun. It is caused by the light shining through a cloud of ice particles, high above the earth. Such rings probably have little, if any, influence on the weather.

A Weather Sign.—This is how a rainbow looks in the Grand Canyon National Park, Arizona. Rainbows are not only beautiful to see, but may serve as weather signs. Do you know how?

Fred Ragsdale



Stratus Clouds.—"Stratus" means "spread out," for these clouds are large, fog-like, and formed near the earth. They are usually seen early in the morning or late in the evening when the air is still.

A colored ring close about the moon or sun is called a *corona*, while the larger rings are called *halos*. The first is usually caused by water particles and the latter by ice particles.

RAINBOWS AND RAIN.—"Rainbow at morning, sailors take warning; rainbow at night, sailors delight." There is some scientific reason in this "sailor's warning." There are some facts we must know in order to understand why it is so.

A rainbow is caused by the sun shining on particles of moisture in the air. In order to see a rainbow, the observer must be between the sun and the rainbow. Another fact we must know is that the usual course of a storm is from west to east.

Now, how does a rainbow tell about the weather? If a rainbow is seen in the morning, it must be seen in the west. This is because the sun is in the east in the morning. If a rainbow is seen, it means that there is moisture in the air. Therefore, a rainbow in the morning tells us that there are rainclouds or moisture-laden air in the west. And we know that this moisture will probably be carried eastward to us.

The rainbow at "night" will be in the east, not the west. The sun's rays are passing through clear air in the west. Thus we can be quite sure that the storm clouds are now in the east. Only clear skies will be brought to us from the west. Thus the old saying has some basis of fact.

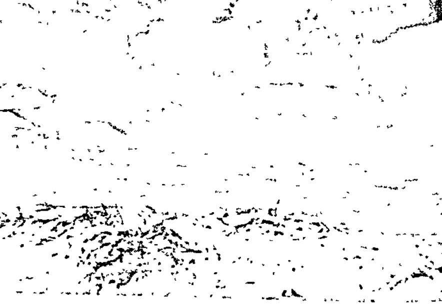
"Rain before seven, stop before eleven" is often true, but not because "seven" rhymes with "eleven." It is usually true because the heat from the sun during the middle of the day warms the clouds. This causes their moisture to evaporate. Also, most storms do not last more than four hours. If it is raining before seven o'clock, the chances are that the storm will be over by eleven o'clock.

CLOUDS.—You know that there are fair-weather clouds and storm clouds. While study of clouds alone will not give reliable weather forecasts, still a close observer of clouds is able to tell some things about approaching changes in weather. This is because different kinds of clouds are due to changing air currents, temperature, and amount of moisture in the air.

Some clouds are well known as fair-weather clouds. You have seen them, the white billowy clouds. They look like great piles of fluffy cotton with flat bases moving slowly along in the sky. These *cumulus* (hillshaped) clouds float at a height of about a mile above the earth, where the air is cool. They are fair-weather clouds when the air is dry. But when warm air, filled with moisture, rushes upward, it cools rapidly. This causes condensation of the moisture. The front edge of the cloud assumes a dark, threatening appearance. The peaceful cumulus cloud thus becomes a threatening thunderhead.

Cirrus Clouds.—These are the "mare's tails" which often cause "lofty ships to carry low sails." Composed of ice particles, cirrus clouds are the highest of the common clouds. Often they are advance warning of a storm.

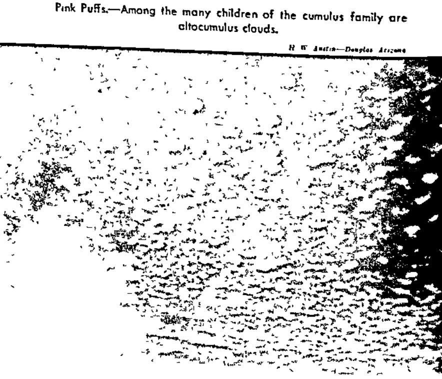
Courtesy National Youth Administration



Fair-Weather Friends.—These cumulus clouds floating above a Cape Cod sand dune suggest good swimming weather.

Pink Puffs.—Among the many children of the cumulus family are altocumulus clouds.

H. W. Austin—Douglas, Arizona



Contrasted with the cumulus clouds are the fleecy, feathery clouds that are often observed high in the sky. These are the *cirrus* (curl) clouds. Highest of all clouds, cirrus clouds often float five or six miles above the earth. Seldom are they nearer than three or four miles. They are near the top of the *troposphere*, the cloud-bearing part of our atmosphere. Above this is the *stratosphere*, a region without clouds. The upper troposphere is a region of very cold air and the clouds there consist of ice crystals. These cirrus clouds are usually the advance guard of a storm. They travel with rapidly moving air currents, sometimes nearly 100 miles an hour.

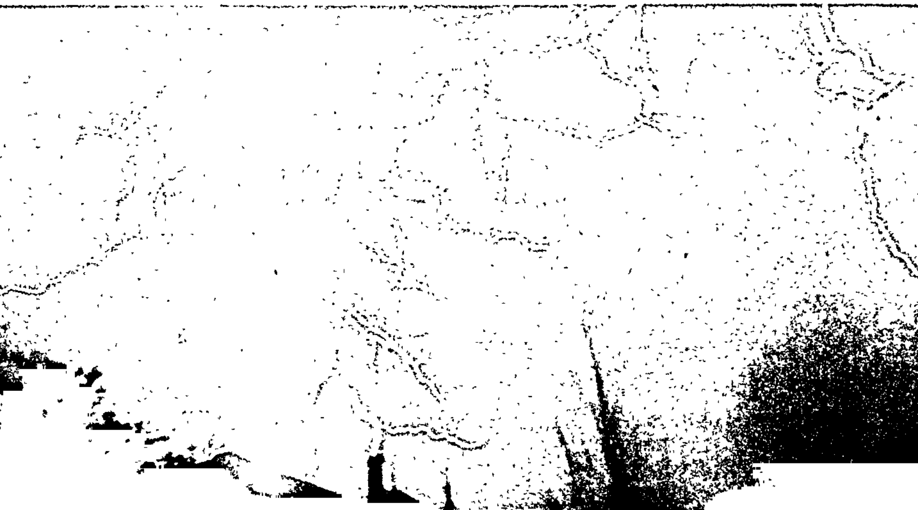
As the storm nears, the cirrus clouds may change to low-lying *stratus* (layer) clouds. Stratus clouds can change into *stratocumulus* clouds. They are called *nimbostratus* if rain falls from them. Stratocumulus clouds hang low in the sky and are wide in extent. These are the clouds often seen at sunset, just above the horizon.

Each of the common kinds of clouds mentioned often combines with others or changes into one of the other three forms. Frequently more than one kind of cloud can be observed in the sky at a time.

All told, there are over twenty-seven kinds of clouds which are combinations of the simple cloud forms. Nine of these

Nature's Anger.—Peaceful cumulus clouds can easily change into black thunderheads. Then we may see an exhibition like this.

H. W. Austin—Douglas, Arizona



Courtesy Standard Oil Co. (N. J.) Photo by Rosskam

Nimbostratus Clouds—These nimbostratus clouds are over the Mississippi River at Natchez, Miss. These are rain clouds which were probably formed from stratus and cumulus clouds. Notice the rain falling in the left half of the picture.

cloud forms, based on the cumulus cloud, are low (L) clouds. Another nine, also having cumulus characteristics, occur at higher altitudes in the air and are referred to as middle (M) clouds.

A third kind occurring at high altitudes is grouped as high (H) clouds. They are the various kinds of cirrus clouds. Weather observers often use symbols in reporting the different forms of clouds. The symbols for some of the common clouds are shown on page 98.

FIELD RESEARCH

Take pictures of clouds and label them with the proper symbol. Not only will you get some beautiful cloud pictures, but you will have pictures to mount in your Science Discovery Book to illustrate your discussions.

ARE YOU SCIENTIFIC?—We have learned that there are many scientific weather signs. We know also that there are many weather superstitions. Superstitions of any kind always indicate ignorance on the part of people who believe them. People who accept superstitions either are not careful, accurate thinkers, or they have never had the opportunity to learn the facts.

You have the opportunity to study science. You will be able to discover the facts about your environment. But you must also be a careful, accurate thinker so that you can use the facts. The scientific study of nature has revealed facts which disprove many superstitions. Yet there are some people who have refused to accept the scientific evidence. You as a scientist should know the difference between evidence and guesswork, between fact and superstition.

Most of all, as a scientist, you should always have an open mind. *You should be ready to accept knowledge that is based on facts.* The true scientist is a seeker after truth.

THINKING THINGS OVER.—The scientific forecasting of the weather requires a knowledge of the weather factors, their causes and effects. Weather signs are often based upon observations that are not fully explained by the principles of science. Usually the observer does not take the trouble to check his prediction of the weather with what actually follows. Often he does not consider the weather that precedes his observation. The weather of tomorrow grows out of the weather of many yesterdays and of today.

As we continue our study of the weather, we shall learn how weather scientists use a vast amount of accurate information. They record wind, air moisture, temperature, air pressure, and the movements of great air masses across the country. These are the weather factors.

KEY WORDS

Words are useful to convey our ideas to others. Proper choice of words will lead to the clearness and understanding which are so necessary to successful work in science. It was the custom of certain ancient philosophers to use words to express ideas without the foundation of proof by experiment. Hence they "confounded their ideas with words." In science, words are used to express ideas based upon facts and their relationships.

Your science study provides you with an opportunity to discover facts and their relationships. You will need the right words to indicate these facts.

The *Key Words* at the end of each topic deserve your special study in this respect. Be certain that each *Key Word* has a real meaning for you so that you can use it without "confounding your ideas." Always complete the *Key Word* exercise in your Science Discovery Book to the best of your ability.

cirrus	evaporate	rainbow
cloud	facts	reason
corona	foretell	ring
crescent	halo	stratus
cumulus	migrate	superstition

Key Statements

Key Statements appear at the ends of topics throughout this book. They express key thoughts based on facts learned in each topic The *Key Statements* will help you to express your understanding of these facts and the relationships between them

Mere memory of these statements, however, will be of little use. To be of value they must have real meaning for you Test your understanding by discussing each *Key Statement* in some detail. Your Science Discovery Book, too, will give you good suggestions for testing your understanding of these important *Key Statements.*

1. The sun, the earth, and the earth's motions are closely related to weather.

2 Superstitions are not founded on fact.

3 Only people who are ignorant of the facts are superstitious. Their superstitions tend to keep them ignorant

4 One cannot foretell the weather by observing animals

5 The moon does not influence the weather

6 Certain natural phenomena, such as rings and rainbows, do have some significance with regard to the weather

7 Cloud formations indicate coming weather to some extent.

8 Scientific weather forecasting depends upon exact knowledge of many weather factors

Thought Questions

1. How can you distinguish between a superstition and a fact?

2. Why is it that a ring around the moon may indicate certain weather conditions?

3 Explain why "sailors take warning" when they see a "rainbow in the morning"

4 Why is the rainbow method of predicting weather less satisfactory than getting information from a weather bureau?

5. How can one overcome a superstition?

6. Do you think there is any truth in the following rhyme?

> When the wind is in the north, you should not venture forth.
>
> When the wind is in the east, it is bad for man and beast.
>
> When the wind is in the south, bait is blown into the fish's mouth.
>
> When the wind is in the west, then the fishing's best.

Projects for Your Science Discovery Book

These projects are for your own scientific investigation and report. They should be completed as directed by your teacher. This is your opportunity to do some original and independent work, and to prove your ability as a scientist. Be sure to enter your findings on each project which you complete in your Science Discovery Book. The projects may be worked out on notebook paper and inserted at the proper place. Use drawings wherever you can for illustration.

1. Keep a record of the changes of the moon and changes of the weather for a few months. Use your records to discover whether or not there is any relation between them. How many sayings do you know about moon and weather?

2. Try to discover how some superstition about the weather started.

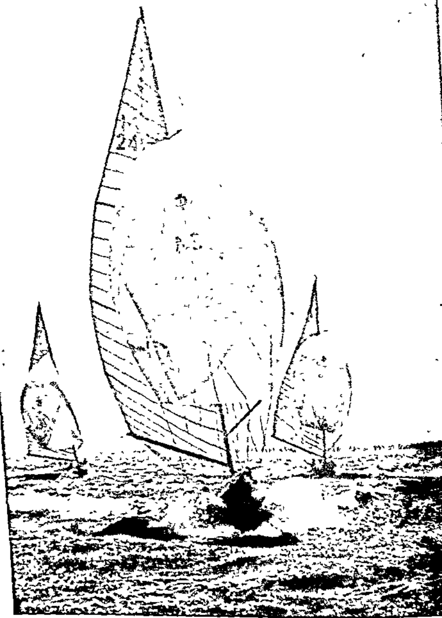
3. Experiment with a glass prism and sunlight to discover how rainbows are formed.

4. At what time of day would a rainbow show the largest curve? The smallest curve? Why does one never see a complete circular natural rainbow in the United States?

5. Report on what you can discover about the reasons for the migration of birds.

6. Make a rainbow by spraying water into the air when the sun shines. Remember the spray must be viewed from a particular angle.

7. Collect as many weather statements as possible relating to rings, rainbows, and other atmospheric conditions. Examine each statement to determine whether or not it has any foundation in facts.



Morris Rosenfeld

Racing the Wind.—A bright sun, sparkling water, warm air, and a spanking breeze—perfect sailing weather. Weather is not always as perfect as this. As the weather factors change, they bring about different weather conditions.

TOPIC II

Weather Factors

DO YOU KNOW—

1. What weather is?
2. How a thermometer works?
3. What air pressure is?
4. What a barometer is?
5. What causes winds?
6. How to tell the amount of moisture in the air?

GENERAL PROBLEM 1

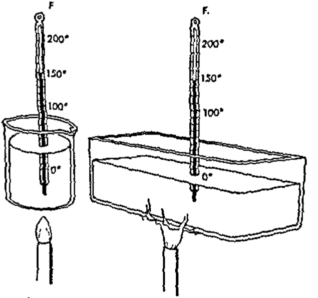
What Is Temperature?

NATURE'S WEATHER-MAKERS.—Nature's principal weather-makers are *air temperature*, *air pressure*, *air motion*, and *air moisture*. Temperature is important because a change in temperature affects the pressure, the motion, and the moisture of the air. Varying pressures are the cause of the winds, which are simply air in motion. Finally, the moisture in the air is seen in clouds, fog, rain, mist, and snow. The shapes of clouds depend on air pressure and temperature. The speed and direction of clouds follow the motion of the air. Thus each of these weather-makers affects the others. Together they are the weather.

WHAT IS TEMPERATURE?—It is easy to say, "It is hot" or "It is cold." But what do these expressions "hot" and "cold" really mean? Changes in heat and cold in our bodies, in the liquids we use, in the air about us, and in the fires which we build make us very familiar with this weather factor, temperature. Every one of us knows what it is to feel hot or cold. But to be real scientists we need also to know exactly what temperature is.

Temperature is the intensity of heat energy in a body. Or we may say more simply that temperature is the degree of heat of a body. Note carefully that temperature is not the amount of heat in a body. Heat and temperature are not the same thing. Heat (energy) is a cause of temperature. Energy, which causes a feeling of warmth in a body, tends to move from a body of higher temperature to one of lower temperature. One body is hotter than another, if it can give heat to the other.

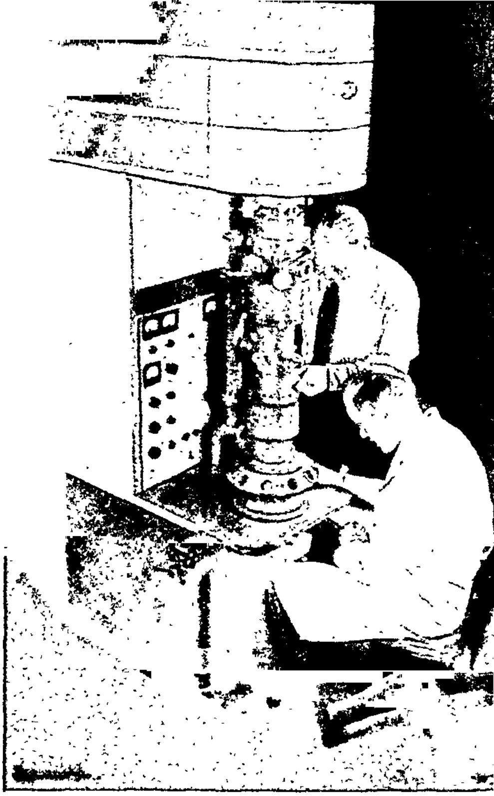
Perhaps you will understand this better if you think of a glass of water and a boiler of water. If both are heated to the same temperature, the boiler of water will have more heat energy because there is more water. The boiler will not give off heat to the glass though, because they are both the same temperature. The difference between heat (energy) and temperature is shown in the diagram.



Temperature and Heat—The temperature of the water in each container is 150°. Does the water in each contain the same heat energy?

All of these statements merely tell us some facts about temperature. They do not tell us what temperature is. Do you remember that all substances are made of molecules in rapid motion? We cannot see molecules with the naked eye.

Some of them, however, have been photographed by means of high-powered microscopes and special cameras. Thus earlier beliefs about molecules have been proved true.



Courtesy Radio Corporation of America

Electron Microscope.—Microscopes like this one have revealed the smallest things ever seen. These microscopes use a beam of electrons (negative charges of electricity) instead of light rays. Single molecules have been photographed by means of the electron microscope.

If two substances are alike in all respects except temperature, the molecules in the one with the higher temperature are moving faster than the molecules in the one with the lower temperature.

You know that when water is heated hot enough, the liquid changes to steam. We believe this happens because the molecules move so fast they fly out of the liquid. Thus they form a gas. Of course the molecules continue to move faster than they did in the liquid state.

When heat is taken away from the steam, the molecules move more slowly and form the liquid state again. If still more heat is taken away, the liquid freezes, or becomes solid. In the solid form of a substance the molecules move more slowly still.

These examples are given to help you understand that temperature is really the state of motion of molecules. The faster the motion, the higher is the temperature.

How Hot Is It?—Now that we have considered the meaning of temperature, we are ready to think about its measurement. Not only can the temperature of objects on the earth be measured, but scientists even have ways of measuring the temperature of stars. The temperature of stars many trillion trillions of miles from the earth has been measured

You have noticed at times that when you enter a room, the air feels colder or warmer than it does at other times. This is often true even though there has been no actual change in the temperature Can you explain the apparent difference? It may have to do with the amount of moisture in the air, or the motion of the air, or both Or perhaps you are not a good temperature measurer

FIELD RESEARCH

Place one hand in hot water and the other in cold water for two or three minutes, and then place both hands in lukewarm water. Explain your sensations

Such experiences with air temperatures and hot and cold water prove that our sense of feeling is not a good measure of temperature. Therefore, scientists have invented certain instruments, called thermometers, which will measure temperature accurately.

GENERAL PROBLEM 2

How Are Temperatures Measured?

METALLIC THERMOMETERS.—Many common household thermometers contain no liquid They are usually circular in shape The temperature is indicated by a pointer which moves across a scale

Inside the thermometer is a *bi-metal* strip, made of two different metals fastened together The bi-metal strip is attached to a pointer When the metals are heated, one expands faster than the other This causes the bi-metal strip to curve or bend. Thus the pointer attached to it moves.

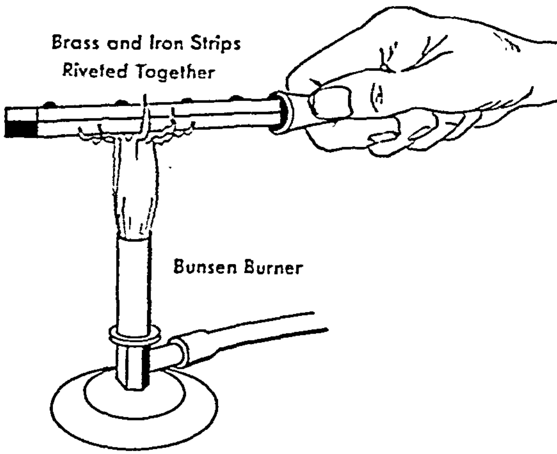
When the bi-metal strip is cooled, one metal contracts faster than the other. This causes the strip to straighten. The pointer then moves in the opposite direction than it did when the bi-metal strip was warmed.

A metallic thermometer is better than a liquid thermometer for many purposes Frequently a metallic thermometer is easier to read. It is not so delicate as a liquid thermometer. Thus metallic thermometers are being used more and more at home.

The mercury-containing liquid thermometer gives a higher degree of accuracy. It is usually employed in scientific work.

EXPERIMENT I

How can metals be used to show changes in temperature?



Before you start this experiment and other experiments, be sure you know exactly what you want to find out, and have everything ready to use.

Have a reason for what you do, and watch everything that happens, so that you can explain it. For instance, why must the brass and iron strips be riveted together? Why does the wood handle not get hot?

What to Use.—Two strips of metal, one brass and one iron, riveted together; a Bunsen burner or some other means of heating the metals.

What to Do.—Heat the strip hot, and then cool it.

What Happens.—1. Does the strip curve when you heat it? 2. If it bends, which metal is on the outside of the curve? 3. Does it straighten out when it gets cold again?

Conclusion.—Can you think of an explanation of the bending? When metals are heated, they expand. Suppose one of the metals expanded faster than the other. Does that help explain your observation?

Application.—Secure a discarded oven thermometer. Take it apart and find the two metal strips.

FIELD RESEARCH

Visit a watch repair man and find out how the balance wheel helps to regulate a watch

There are many devices which you can find out about, all using double strips of metal as a metallic thermometer One of them is the thermostat used to control the temperature of houses and boilers. Thermostats are also used to regulate the flow of water in an automobile radiator

THERMOMETERS CONTAINING LIQUIDS.—Liquid thermometers consist of a glass *bulb* and *stem* They are nearly filled with a liquid, called *mercury*, or with red-colored alcohol or a similar liquid The stem of the thermometer has a very fine *bore* (lengthwise hole) The stem is sealed at the top and broadens into the bulb at the bottom

In order to understand how a liquid works in a thermometer, you must remember what happens when a liquid is heated. Any liquid, such as mercury, alcohol, or water expands when it is heated That is, heat causes it to increase in volume. Mercury and alcohol expand uniformly. They expand equal amounts with equal changes in temperatures, at least for ordinary changes.

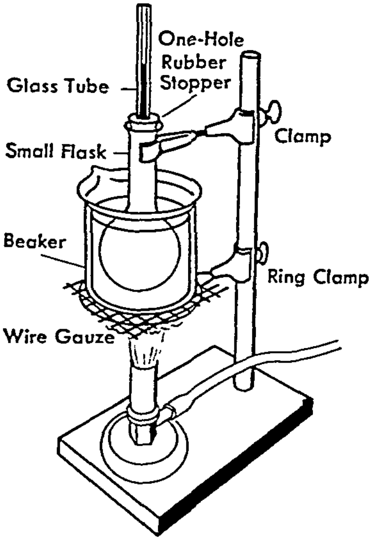
The freezing and boiling points of mercury and alcohol occur at convenient temperatures Thus these liquids make splendid indicators for use in thermometers For example, if a liquid freezes at 20° F., it could not be used for temperatures below 20° F. On the other hand, a liquid to be used in a thermometer must have a boiling point higher than the temperature it is to measure Mercury (quicksilver) has a freezing point of −37° F. and a boiling point of 675° F. It can therefore be used between those temperatures. Alcohol freezes at − 179° F. and boils at 172° F. Therefore, alcohol cannot be used for temperatures above its boiling point, namely, 172° F.

You have seen examples showing that liquids expand when heated and contract when cooled This is to be expected if what we think about the motion of molecules is true. As the molecules move faster they take up more room.

Experiments 2 and 3 will help you to prove what happens when liquids are heated and cooled.

EXPERIMENT 2

Do liquids expand when heated?



You could do this experiment without putting the flask of water in a beaker of water, by applying heat directly to the flask itself. Why do you think it is better to do it as shown in the diagram?

If the hole (bore) in the glass tube were smaller, would the water level in it move up and down more than in this size tube? Why?

What is the need for the wire gauze?

WHAT TO USE.—A small (50 cc.) flask: a one-hole rubber stopper to fit the flask; a glass tube 12 inches long to fit the hole in the stopper; a large glass beaker or basin of water; a Bunsen burner; a clamp support for the flask; and a ring support, wire gauze and ring stand to support the beaker.

For home experimenting a pickle bottle partly filled with water can be heated in a double boiler on the stove.

WHAT TO DO.—1. Fill the flask brimful with water and insert the stopper with the glass tube just sticking through it. The water will probably fill the flask and a little of the glass tube. The top of the water in the tube should be marked by tying a string around it at that point or by some other means.

Support the flask with the bulb immersed in cold water in the beaker. The beaker should be placed on a wire gauze on the ring.

2. Heat the water in the beaker for a few minutes, and mark the new level of the water in the tube as before.

WHAT HAPPENS.—1. When the stopper was inserted in the flask, did some water go up into the glass tube? Why?

2. When you heated the water in the beaker, did the water in the flask get hot? How?

3. Did the level of the water in the glass tube go up or down as you heated the water in the beaker? How much did it change?

CONCLUSION.—Why did the level of the water in the tube change? Did the water in the flask take up more room when it became hot than when it was cold? Why?

APPLICATION.—How does the liquid in a thermometer indicate higher temperatures?

If the radiator of a car is filled to the brim with cold water, will some water overflow when the radiator gets hot? Why?

When the bulb of a thermometer containing mercury or alcohol or any other liquid is heated, the liquid in the bulb expands (takes up more room). This causes the liquid in the stem to rise higher If the liquid in the bulb of the thermometer is cooled, it contracts and the liquid in the stem goes down.

Perhaps you are wondering why thermometers have bulbs. The bulb is to hold the liquid. The bore in the stem is small so that when the large amount of liquid in the bulb expands even a little, the top of the liquid in the stem moves a good deal. The bore is sometimes so small that the thread of liquid in it is difficult to see unless it is magnified in some way.

Let us try Experiment 3 to prove that liquids contract when cooled.

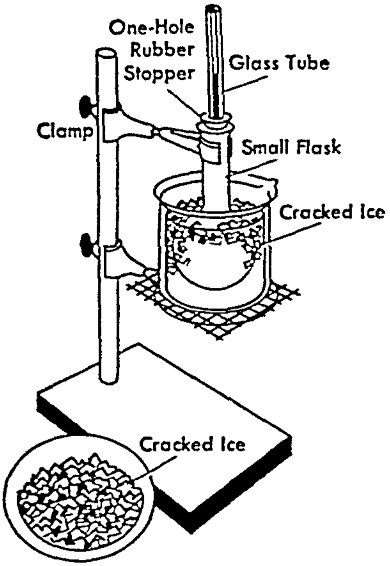
FIELD RESEARCH

If you have an ice-cube freezer in your refrigerator at home or at school, try the following Fill a tray as nearly level with water as you can Then put it in the refrigerator and let the water freeze. When it is frozen solid, note if the ice takes up more room than the water. Does water expand when it freezes?

THE FAHRENHEIT SCALE.—One of the first thermometer scales was made by a scientist named *Fahrenheit* who was born in Danzig in 1686

The common house thermometer has a Fahrenheit scale. When the bulb of a mercury thermometer is placed in melting snow or ice, the top of the mercury will drop to a certain level in the stem and stay there. This place on the stem is marked 32° on the Fahrenheit scale. If the bulb of a mercury ther-

Do liquids contract when cooled?



When you look over the apparatus for this experiment, do you see a good reason for putting the flask in a beaker of water? What is used in this experiment to cause the water in the flask to change in temperature? What was used in Experiment 2 to cause a change in temperature? Is the wire gauze needed here for the same reason it was used in Experiment 2?

WHAT TO USE.—Use the same equipment as in Experiment 2 except the Bunsen burner.

WHAT TO DO.—Fill the flask so full that, when you put the stopper in, some water rises in the tube. Place the bulb of the flask in cold water in the beaker, and add cracked ice. At home the pickle bottle can be placed in the refrigerator.

WHAT HAPPENS.—Describe just what changes you observe.

CONCLUSION.—Do liquids contract when they are cooled?

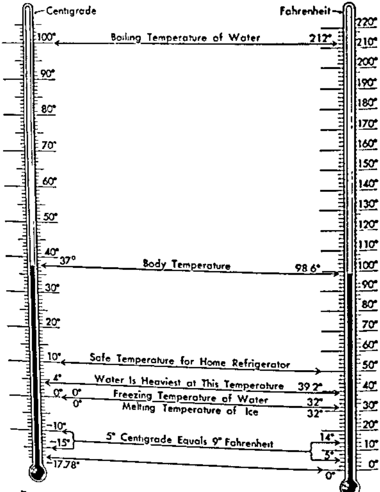
APPLICATION.—Why does the level of the water in an automobile radiator drop as it cools?

How does the liquid in a thermometer indicate lower temperatures?

mometer is placed in boiling water or steam at standard air pressure, the liquid will rise to a certain level. This place on the stem is marked 212°.

The stem between the 32° mark and the 212° mark is divided into 180 equal divisions. Each one of these divisions is a *degree*. The 32° mark is the temperature at which ice or water freezes The 212° mark is the temperature at which water boils under standard air pressure These two marks are sometimes called the "fixed points" of a thermometer. They can be used for testing the accuracy of a thermometer.

You can test the accuracy of a mercury thermometer by following the plan in Experiment 4



Temperature Scales.—Compare the fixed points on each scale. Which is larger—one degree Fahrenheit or one degree Centigrade? The Fahrenheit reading equals the Centigrade reading multiplied by 1.8 plus 32. Try it.

LIBRARY RESEARCH

Consult your librarian for information about Fahrenheit. Find out how his first thermometer was marked and how the changes to the present markings happened to be made.

THE CENTIGRADE SCALE.—The *Centigrade* thermometer scale differs from the Fahrenheit scale in divisions and the numbers for the "fixed points." On the Centigrade thermometer, the point at which the liquid in the stem should stand when the bulb is in melting ice is marked 0° C. The level for boiling water is marked 100° C. The space between 0° C. and 100° C. is divided into 100 divisions, hence the name *centi* (hundred) *grade* (marks). A thermometer with a Centigrade scale may be tested in the same manner as the Fahrenheit.

The Centigrade scale is the most commonly used scale in science. Measurements on the Centigrade scale can be divided into tenths, hundredths, and thousandths by changing the position of the decimal point. The meter is also divided into tenths, hundredths, and thousandths. The meter belongs to the metric system, which is used by scientists the world over. Compare this with our yard, which is divided into 3 feet and 36 inches.

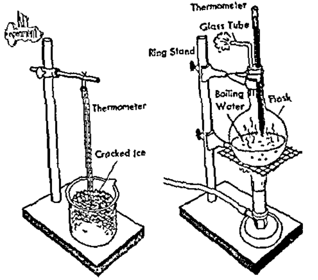
LIBRARY RESEARCH

With the help of your librarian and your science teacher look up the metric system and learn its advantages over the English system for use in science.

COMPARING THE FAHRENHEIT AND CENTIGRADE SCALES.—You can compare these two common scales by studying the diagram. Notice that the bulbs and the stems are exactly the same. Note also that both use the same kind of liquid. For a given degree of heat, the liquid in each stands at the same height. But the *markings* on the stems are different. Thus 100° C. is just as hot as 212° F. Compare the readings shown on both scales. Then try to answer the question under the diagram.

(KEY) EXPERIMENT 4

How may a thermometer be tested by its "fixed points," 32° and 212°, to determine its accuracy?



Why is it a good thing in this experiment to heat the flask of water directly with the flame instead of in a beaker of water as in Experiment 2? What use has the wire gauze?

Why do you suppose the thermometer bulb is placed just above the boiling water and not in it? Suppose you try it both ways

In the part of the experiment with ice, why would you have to leave the thermometer bulb in the ice longer if the bulb were larger?

This is a "Key," or especially important, Experiment

WHAT TO USE —A glass mercury thermometer that has a 32° and 212° mark, cracked ice, a beaker, a flask with 2-hole rubber stopper; a ring stand with ring support, wire gauze, Bunsen burner, glass tube.

WHAT TO DO —1 Test the position of the 32° mark by placing the bulb in a small beaker filled with cracked ice and a little water. The temperature of a mixture of melting ice and a little water is 32° F.

Leave the bulb in the melting ice until you are certain the mercury in the stem will drop no lower All the mercury in the bulb is then at the same temperature as the melting ice.

2 Now carefully observe the 32° mark on the stem to determine whether it is exactly on a level with the mercury in the stem. If it is, the thermometer is accurate as to this fixed point. If it is not, make a note of the amount of difference, above or below.

3. To test the 212° mark on the thermometer, place the bulb in the steam of boiling water. Insert the thermometer through one hole of the 2-hole rubber stopper and place the stopper in the flask about $\frac{1}{4}$ full of water. The bulb of the thermometer should be just above the surface of the water. In the extra hole in the rubber stopper place a tube to allow steam to escape from the flask; otherwise it will burst. Support the flask and heat the water to boiling.

The temperature of the boiling water increases with increased air pressure and lowers with reduced air pressure. Therefore, results may not be as accurate as for the other test but will be accurate enough for your purpose. The steam from boiling water for a given pressure stays at the same temperature as long as the water boils.

Check the position of the 212° mark with the top of the mercury. What does it show?

WHAT HAPPENS.—1. In the first part of the experiment, did some of the ice melt?

2. Was the 32° mark exactly opposite the top of the mercury? If not, how much was it in error? + or −?

3. In the second part, was the 212° mark exactly opposite the top of the mercury in the stem of the thermometer? If not, how much was it in error? + or −?

CONCLUSION.—State how accurate you found the thermometer as indicated by the 32° and 212° marks.

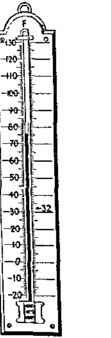
APPLICATION.—Commercial thermometers are calibrated (marked for reading) by placing them in constant temperature baths and marking the mercury (or liquid) level for certain temperatures. Then with a dividing machine the stem is marked off into equal spaces with these marks as starting places. Or the spacing of the marks is transferred to the metal back.

Use a tested thermometer to check one that may be inaccurate.

NOTES.—1. A thermometer with a wooden back should not be placed in boiling water, for the hot water may injure the finish on the wood.

2. A thermometer that does not register as high as the 212° mark should not be used, since placing it in boiling water might cause it to break.

THERMOMETERS FOR SPECIAL NEEDS.—The doctor uses a small thermometer of special make to "take" (measure) the temperature of a sick person. The normal temperature of a healthy body is 98.6° F. A slight difference above or below normal indicates trouble. It is necessary therefore for the doctor's thermometer to be very accurate.



House Thermometer

This thermometer does not read beyond 130°. Is that satisfactory for its purpose?

Can you test this thermometer by the boiling-point test?

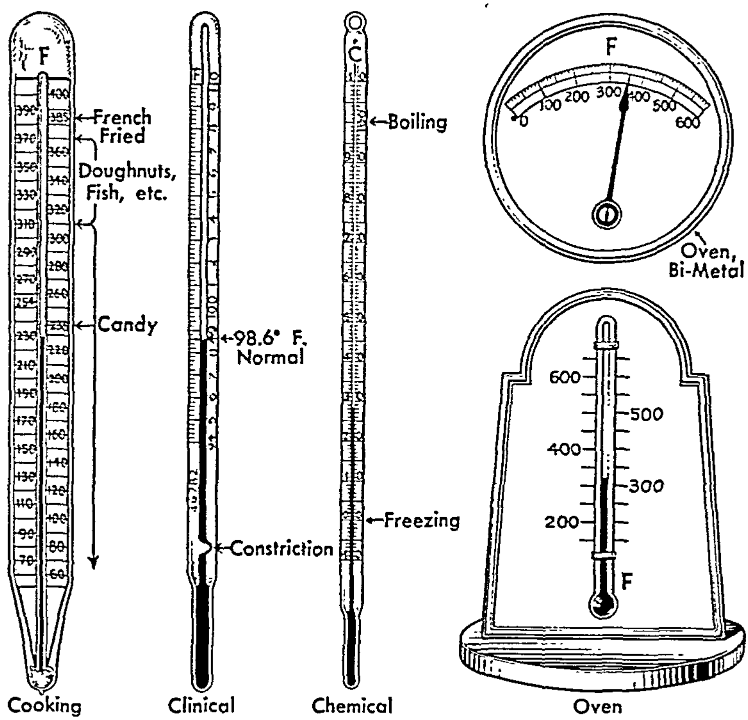
Can you check its accuracy by the freezing-point test?

The doctor's thermometer is called a *clinical* thermometer. It has a short stem with a much smaller bore than ordinary thermometers Thus a slight change in temperature will cause a considerable change in the level of the mercury in the stem.

The front part of the glass stem is shaped in such a way as to act like a lens It magnifies the small thread of mercury in the bore so that it may be seen more readily. The face of the stem is marked off in units of one fifth of a degree. Between the long slender bulb and the stem, the bore is made even smaller than the bore above or below (see the picture on page 35). Because of this, once the mercury gets above the squeezed-in part, it is not drawn back into the bulb when the thermometer cools. Such a device allows the doctor time to read the temperature accurately. Perhaps you have seen him "shake" the mercury back into the bulb after he has read the temperature.

Some other special thermometers are used for making candy, deep-fat cooking, making maple sirup and sugar, cooking meats, and for a great many industrial processes. The special thermometers may contain liquid or they may consist of two metal strips called metallic thermometers.

As you have learned, mercury is not the only liquid used in thermometers. Some contain colored alcohol or similar liquids. One point to remember is that different liquids have different boiling temperatures Alcohol, for example, boils at about 172° F. Therefore an alcohol thermometer may not be used



Thermometers.—How many of these thermometers do you recognize? Which one has the greatest range? Which one reads the highest? Why? Which do you think is most accurate? Why wouldn't an oven thermometer make a good cooking thermometer?

safely for temperatures as high as that. On the other hand, alcohol must be cooled to a much lower temperature than mercury to freeze. This means that alcohol thermometers can be used to measure much lower temperatures than can mercury thermometers.

FIELD RESEARCH

Have you ever noticed that many types of thermometers in use around you? Select a committee to survey and report on the thermometers in use in your school. Ask the committee to list all the different ones. If possible, have the committee bring the thermometers into class for your inspection. If this cannot be done, the committee may prepare large drawings of the thermometers.

What Causes Differences in Air Temperatures?

DIFFERENCES IN AIR TEMPERATURES.—Latitude, wind direction, altitude, and large bodies of water are the principal regulators of air temperatures over the earth. We shall learn later that the sun has very little *direct* heating effect on the air.

EFFECT OF LATITUDE.—Latitude influences air temperatures because the farther a place is from the equator, the more the earth slopes away from the sun's rays. Or to put the fact another way, the more slanting the rays of the sun, the less heat the rays supply. Thus the Frigid Zones are much colder than the Temperate or Tropic Zones.

But we must be careful not to think that a place will have a uniform temperature because of the zone or latitude in which it lies. The other regulators of temperature cause it to change a good deal. For example, air temperatures in the Temperate Zones range from 60° below zero to 110° above.

We should remember, then, that the temperature zones shown in the diagram on page 39 represent only general conditions of temperature. Their real purpose is to show the changes in the direction of the sun's rays caused by seasonal changes. We shall consider the heating effects of these changes in more detail when we study the seasons.

Semi-tropical Climate.—Winds from the Gulf Stream blow across the Bermuda Islands. How does that fact help explain Bermuda's climate?

Bermuda News Bureau

Winter Wonderland.—Although snow may cause great damage and much inconvenience, it also paints beautiful pictures. Why is a scene like this common in northern United States but rare in the South?

Effect of Winds.—The temperature of the air of a place is affected by the direction of *winds*. Wind coming from the north is usually a current of cold air, and consequently the temperature of a place in its path will drop. Also, air moving over a body of cold water is cooled and will cool the localities over which it passes.

Effect of Altitude.—Altitude above sea level has a marked effect on air temperature. Even though the top of a mountain is nearer the sun, the air is cooler there than at its base.

Many people wonder why the air becomes colder with increase in altitude. All your experiences show that the nearer you are to a hot stove the warmer you feel. How can it be, then, that it is colder above the earth, which is nearer to the hot sun, than at the lower levels of the earth's surface?

Air near the earth gets more heat from the earth than air above it. Also the upper air does not absorb (take in) as much heat from the sun as the lower air. This helps to make the air near the earth warmer than the air above. Actually, the sun has little effect in warming the air. It warms the earth. The earth in turn warms the air near it.

We know that warm air rises. As the warm air rises, the pressure on it becomes less and less. The molecules spread

Courtesy Los Angeles Chamber of Commerce

Climate and Altitude.—This picture was taken in southern California. In the foreground is a citrus grove In the background is Mount San Bernadino. What two different climates do you see? How can you explain the two climates?

farther and farther apart. The air gets lighter, going higher and higher, farther and farther away from the warm earth. As it rises, it gets "thinner" and colder.

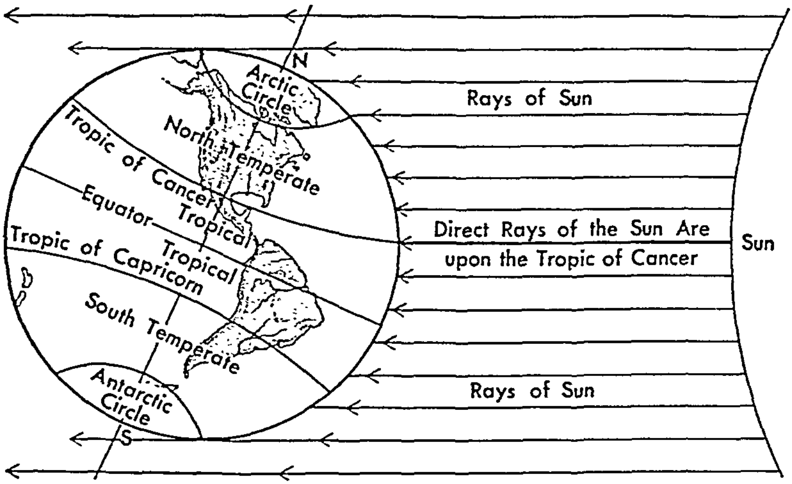
If you apply heat to air, you make it expand If, on the contrary, air is allowed to expand by lessening the pressure on it, it cools off.

Thus the warm air rises, expands, and becomes colder. It rises gradually to about 6 or 7 miles, getting colder all the time by expansion At that height it is so cold it does not rise any higher. It begins to settle back toward the earth's surface. For this reason air gets colder up to about 6 or 7 miles.

Above the height of 6 or 7 miles, air temperature remains about the same, 60° to 70° F. below zero, for several miles. This region of constant temperature is called the stratosphere.

Above the stratosphere the temperature of the air is thought by some scientists to increase as the natural result of being closer to the sun.

Since rising currents of air contain moisture which condenses and forms clouds, the highest clouds are not higher than 6 or 7 miles. As we read on page 15, the layer of air containing moisture and clouds is called the *troposphere.* It reaches about 6 or 7 miles above the earth. Above the troposphere is the cloudless stratosphere.



First Day of Summer.—On the first day of summer in the northern hemisphere the sun is directly overhead at the Tropic of Cancer. What is the northern limit of the sun's rays at this time? the southern limit? What changes would have to be made in this diagram to make it represent the first day of winter? What are the limits of the sun's most direct rays from season to season?

Effect of Near-by Water.—The temperature of the air of certain places near the ocean is also affected by the great ocean currents. These currents are like huge rivers flowing in the ocean itself. If the current comes from the Tropical Zone, as the Gulf Stream does, its waters are warm and will heat the air of places near it. On the other hand, if the current comes from the north, its waters are cold and will make the air of near-by places colder.

LIBRARY RESEARCH

Ocean currents owe their motion partly to the fact that cold water is heavier than warm water and partly to winds. The direction of ocean currents is influenced by the rotation of the earth as well as by wind direction. Follow up these hints by further reading to determine why a particular ocean current takes the course it does.

GENERAL PROBLEM 4

How Can Air Pressure Be Measured?

THE AIR AROUND US.—The earth is covered with an ocean of air called its *atmosphere*. There is really no "top" or upper surface of the atmosphere, as there is to the water ocean. The atmosphere merely thins off into space.

In your earlier science study perhaps you experimented and found that air is composed of oxygen, carbon dioxide, and moisture. Can you recall how you tested for these three substances? From your reading you learned also that air contains nitrogen and several rare gases.

The air has about the same composition up to an altitude of sixty to eighty miles, except for ozone. However, without special aids to breathing most men cannot live long above three and one-half miles from the earth. Above this height the air pressure is too low for normal breathing. It is possible that above 100 miles the atmosphere contains slowly decreasing amounts of oxygen. It is now believed that there is no hydrogen above 100 miles. Nitrogen is the principal gas at all heights.

WHAT IS AIR PRESSURE?—We know that air is matter and that all matter has weight. *The weight of the air is called air pressure.* A column of air one square inch in area, and as high as the air extends upward, weights 14.7 pounds at sea level under normal conditions. There is a similar column of air over every square inch of ground and every square inch of water. Thus we may say that the atmospheric pressure on the earth is 14.7 pounds to the square inch at the level of the sea.

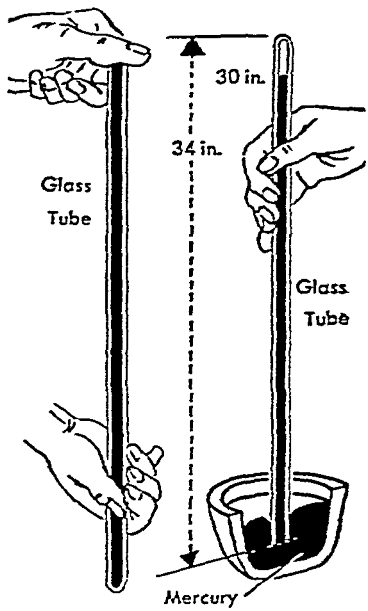
To help you understand about air pressure, think of a large pile of loose straw. It would be pressed more tightly at the

The pressure of the air against this one square inch of white surface is 14.7 lbs.

bottom than at the top, wouldn't it? All the straw at the bottom would bear the weight of all the straw above it. The same is true of air. The lower part of the atmosphere is the most compact or *dense*. The molecules are more closely packed together. As one goes up from the earth, the air becomes thinner (less dense). Therefore, the air pressure decreases very rapidly as one leaves the earth. At a height of about three and a half miles, approximately half of the weight of the air is below one. That is, at that altitude the pressure is approximately 7.3 pounds per square inch.

MEASURING AIR PRESSURE.—Air pressure is measured by instruments called *barometers*. There are two types of barometers in general use, *mercurial* (or *liquid*) and *aneroid* (*without liquid*) barometers. The mercurial barometer was invented by two scientists, Galileo and Torricelli (tôr'rê-chĕl'lē), about 250 years ago.

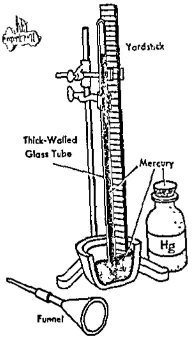
Galileo knew that water would not rise in a pump higher than about 33 feet. He reasoned that the fact had something to do with the pressure of the atmosphere. He asked one of his pupils to solve the problem. The pupil, Torricelli, by his now famous experiment proved that Galileo's idea about atmospheric pressure was correct.



Mercurial Barometer.—The tube is 34 inches long. Would a 36-inch tube be satisfactory? Would a 30-inch tube? The height of the mercury in the tube is measured from the surface of the mercury in the dish. Why doesn't the mercury run out of the tube?

(KEY) EXPERIMENT 5

How does atmospheric pressure affect a barometer?



What new materials are used in this experiment? Why must the glass tube be more than 30 inches long? Why must it be closed at one end?

Mercury is very heavy and easily spilled. Be careful because it is expensive. If mercury gets on a gold ring, the gold will turn white but will be all right again if it is kept warm a while. Try not to get mercury into a cut on your finger. It might make it sore.

This is another "Key" Experiment.

WHAT TO USE.—A thick-walled glass tube 34 inches long, with a bore of $\frac{1}{4}$ inch and sealed at one end, mercury; a ring stand and two clamps, a yardstick, a small, flat-bottomed dish; and a small funnel with small glass tube attached to transfer mercury to the tube.

WHAT TO DO.—1 Set up the barometer as Torricelli did and fasten it in an upright position on the ring stand.

2 At a certain time each day for one week measure the distance from the surface of the mercury in the dish to the top of the mercury in the tube. Record your readings in a table.

WHAT HAPPENS.—1 Did the mercury stay in the tube at a level about 30 inches high? What kept it from flowing entirely out of the tube?

2 Did the height of the column vary from day to day? How much?

CONCLUSIONS.—What is the effect of atmospheric pressure on the mercury column of a barometer?

APPLICATION.—Keep a record of the air pressure and air temperatures for a few days. Note differences or similarities in their readings.

Torricelli used a tube about a yard long, and closed at one end. He filled it with mercury. Placing a finger over the open end, he inverted it, putting the open end in a dish of mercury. On removing his finger, he noticed that not all the mercury came out of the tube. It settled down and came to rest with the top of the mercury in the tube about 30 inches above the surface of the mercury in the dish. (See the diagram of a mercurial barometer on page 41.)

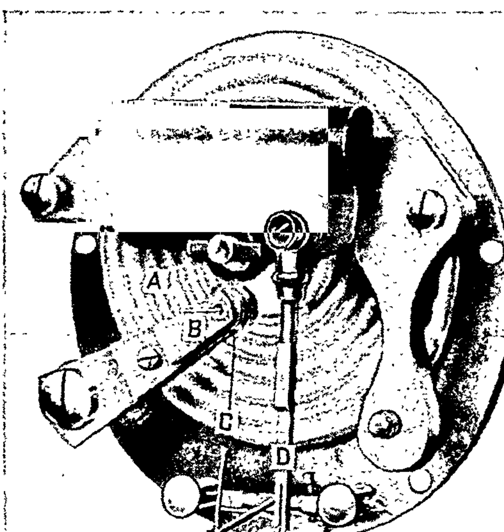
Torricelli reasoned that there was no air in the tube above the mercury. (The tube had been filled with mercury and no air was allowed to enter.) Therefore the column of mercury must be held up or balanced by the pressure of the air on the surface of the mercury in the dish.

You can try Torricelli's experiment by following the directions on page 42. Be sure you can explain why the mercury drops so far in the tube and stays there.

THE ANEROID BAROMETER.—The aneroid barometer is decidedly more convenient for general use than the mercurial barometer. It is a small and light instrument. Moreover, containing no liquid to spill, the aneroid may be carried from place to place easily. Also its readings may be recorded automatically.

The part affected by changes in air pressure is a flat metal box with flexible top and bottom. It contains practically no air. *In*creasing pressures squeeze the top and bottom together.

Aneroid Barometer. — The parts are: (*a*) Metal box, (*b*) Shaft on which pointer is attached, (*c*) Thread, (*d*) Movable bar. The cover and pointer of this barometer have been removed. What is the purpose of the metal box? What causes the shaft to turn?



Decreasing pressures let them spring apart again. These movements are passed along to a pointer on the face of the aneroid by little levers and chains.

UNITS OF AIR PRESSURE —For years, air pressures have been expressed in inches The inches refer to height of the column of mercury in a barometer

In recent years another unit has been used. This unit is called the *millibar* A column of mercury 30 inches high is equivalent to 1015 0 millibars One tenth of an inch of mercury equals 3 4 millibars Because most barometers are marked off in inches, a table showing both inches of mercury and millibars has been placed in the Appendix of this book. Weather maps now use the millibar, so this unit of pressure will be discussed again under weather maps.

GENERAL PROBLEM 5

What Is Wind?

FROM BREEZE TO TORNADO —On a hot summer day you may be enjoying a gentle breeze. In other sections of the country a wind may be blowing with such terrific force that it tears down buildings, pulls up trees, and destroys everything in its path. Such a destructive wind is called a *tornado*. The velocity of a tornado may reach 200 or 300 miles per hour. Wind of ordinary velocity moves from 3 to 15 miles per hour. *Wind is air in motion.*

In order to understand the cause of this moving air, called *wind*, let us consider some common observations. Almost everybody knows that hot air rises. Do you know why? Perhaps you will be able to prove your answer by experimenting at home.

Warm air rises because the heavier cool air settles and pushes the warm air up If air over the earth is heated more in some places than in others, the air will move. The cold air is heavier than warm air and therefore settles, pushing the warm air out of its way. For this reason air will move from a colder region to a warmer region.

TWO KINDS OF WINDS.—Some winds are caused by unequal heating of the air locally. The light summer breeze and the

FIELD RESEARCH

If you have a hot-air furnace in operation, place a *tuft of cotton* or a feather over the hot-air register. Does the cotton move up or down? Which way does it show that the air is moving? If you have no furnace but have a stove, make a little smoke near the stove pipe. Does the smoke go up along the hot stove pipe? Which way is the air moving, up or down?

Open a window a bit at top and at bottom, when it is rather cold outdoors and there is no wind blowing Test the air movement. Does the air come in through the open window at top or bottom? Does it go up or down after it gets in?

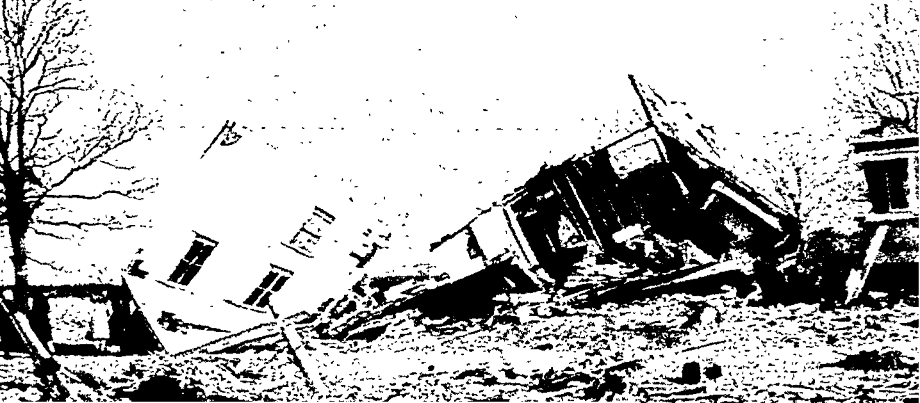
heavy wind that blows before a thunderstorm usually are of this type.

On the other hand, winds may be a part of a great mass of moving air. Such large masses of air move because of unequal temperatures over large portions of the earth's surface. Great masses or blocks of air may measure many miles in width at the front and hundreds of miles in thickness. They are called *air masses.*

Air Masses.—Some air masses move from the cold polar regions southward. If they come from over the continent, they are called *continental polar* air masses. They are referred to by the abbreviation cP.

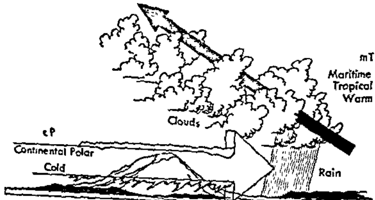
Tornado Damage.—The tornado that did this damage traveled only a short distance and spent its force in thirty minutes. This destruction, however, was done in only a few seconds.

U. S. Weather Bureau



Other great masses of cold air which begin over polar seas are called *maritime* (sea) *polar* air masses. This name is abbreviated mP. If the air mass comes from the continent where the temperature is warm or tropical, it is called a *continental tropical* (cT) air mass. If it comes from a warm sea, like the Gulf of Mexico or South Atlantic or Pacific, it is called a *maritime tropical* (mT) air mass.

These large masses or blocks of air move over the land without being mixed very much unless a cold mass meets a warm mass. Then the *front* of the warm mass may ride up over the *front* of the cold mass, owing to the fact that warm air is lighter than cold air. Where two fronts meet in this way, storms are very likely to occur as a result. This is shown in the diagram below.



When Warm Air Meets Cold Air.—*This diagram shows what happens when a mass of warm air meets a mass of cold air. What happens to the warm air? Explain why clouds and rain result.*

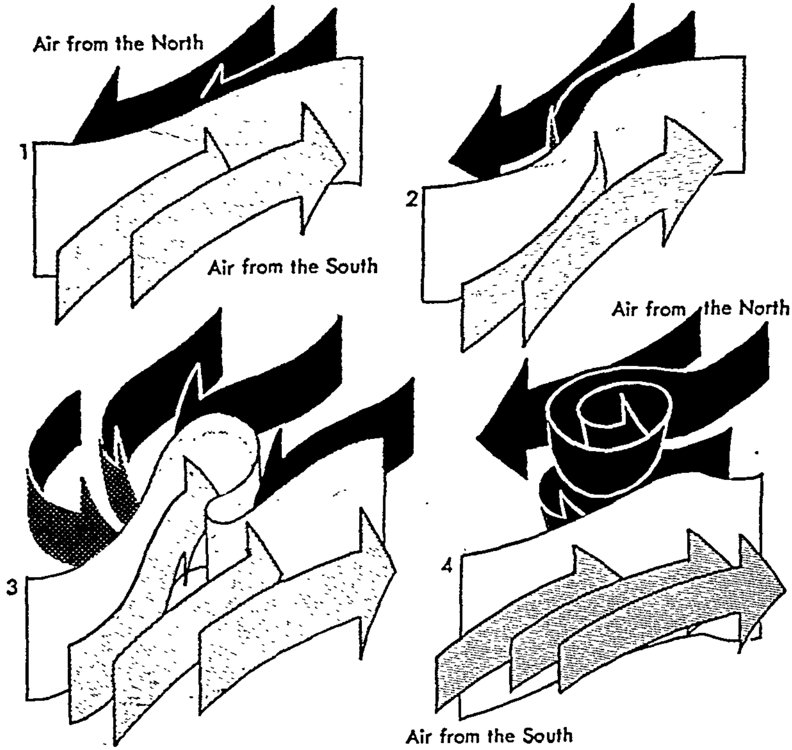
Sometimes the two masses rub shoulders so to speak. This results in the sides of the air masses being mixed up so that storms occur. The diagrams on page 47 explain how this happens.

If a warm mass moving northeasterly meets a cold mass moving southward and to one side, a counter-clockwise whirl of air is produced. This whirl of air is called a *low*. Such a low is in most cases a storm center and is many miles across.

FIELD RESEARCH

One result of this whirling movement of air currents can be illustrated by whirling water in a glass. The water will whirl with the glass but will pile up at the sides of the glass and will be shallow in the center. Try it.

The whirling mass of air (low) acts the same way as the whirling water. The center portion of the whirling mass is shallow and has a low air pressure. That is why it is called a low.



Birth of a Low.—Study these diagrams in the order 1, 2, 3, 4. The white strips show that masses of warm and cold air do not mix. Black arrows represent cold air; gray arrows represent warm air. Scientists now believe that low pressure areas are formed in this way at the boundary of warm air masses and cold air masses.

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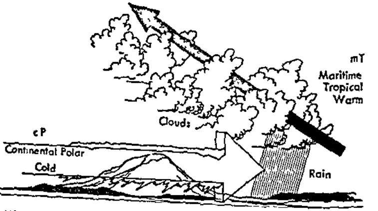

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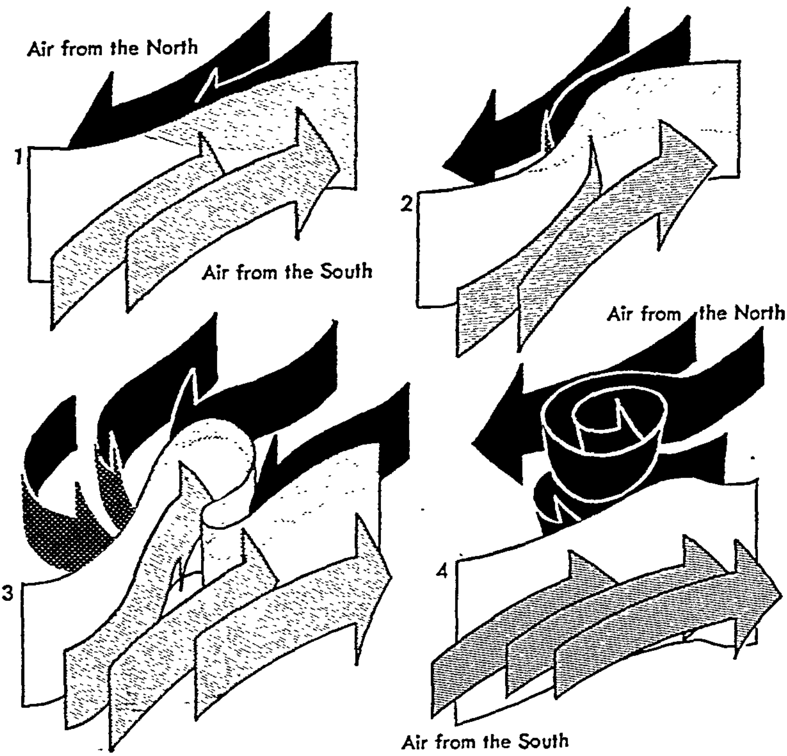

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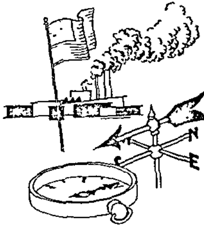
EXPERIMENT 6

How can the direction and velocity of the wind be determined?



This experiment calls for you to use your eyes out-of-doors. If you can observe a weather vane, why do you not need the compass? Could you tell the directions without either a weather vane or compass? How?

WHAT TO USE.—A weather vane (or a magnetic compass); a flag on a pole, and smoke from a chimney

WHAT TO DO —Determine the points of the compass—North, East, South, West, and the middle points between—eight in all. Observe and record the direction of the wind as indicated by the weather vane, flag, or smoke

In your notes you can use the words "North," "North-East," "North-West," etc, to record the directions from which the wind comes, or you can use symbols like those found on the weather maps—a circle with a short line pointing in the direction from which the wind is blowing.

Refer to the table of velocities on page 49 to estimate the velocity of the wind at each observation.

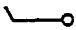
WHAT HAPPENS —Record your observations

CONCLUSION —Tell how you determined the direction and velocity of the wind

APPLICATION —Keep a record of the wind direction and velocity for a few days Discover whether there is any relation between a high wind and a particular direction

WIND VELOCITIES

(From Civil Aeronautics Bulletin No. 25, September, 1940, United States Department of Commerce, Civil Aeronautics Administration, Washington, D. C., "Meteorology for Pilots," by B. C. Haynes.)

Beaufort Number	Map Symbol	Descriptive Word[1]	Velocity (Miles per Hour)	Specifications for Estimating Velocities
0		Calm	Less than 1	Smoke rises vertically.
1			1 to 3	Direction of wind shown by smoke drift but not by wind vanes.
2		Light	4 to 7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
3		Gentle	8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
4		Moderate	13 to 18	Raises dust and loose paper; small branches are moved.
5		Fresh	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland water.
6			25 to 31	Large branches in motion, whistling heard in telegraph wires; umbrellas used with difficulty.
7		Strong	32 to 38	Whole trees in motion; inconvenience felt in walking against the wind.
8			39 to 46	Breaks twigs off trees; generally impedes progress.
9		Gale	47 to 54	Slight structural damage occurs (chimney pots and slate removed).
10			55 to 63	Trees uprooted; considerable structural damage occurs.
11		Whole gale	64 to 75	Rarely experienced; accompanied by widespread damage.
12		Hurricane	Above 75	

[1] Except "calm," these terms are not to be used in reports of velocity.

MOVEMENT OF LOWS.—Lows move in paths across the United States Some lows begin in the southwest and move in a curved northeasterly path over the United States toward the St Lawrence River At the same time, other lows are being formed far out in the Pacific Ocean These pass over the United States in a curved path from the state of Washington and out the St Lawrence River region. When we study weather forecasting, we shall learn more about the movements of the lows and the corresponding *highs*

The *low* is often called a *cyclone* A cyclone has a slower speed of air (wind) and should not be confused with a tornado.

WIND VELOCITIES —The speed with which air moves is an important factor in forecasting the weather. You can learn to estimate wind velocity by using the table on page 49. In making wind observations, it is important also to notice the direction

Winds are named from the point of the compass from which they come. Hence a weather vane, a flag on a pole, or smoke from a chimney will indicate wind direction.

An interesting way to represent wind directions and velocities is found on modern weather maps The location of a weather station is indicated by a circle A short line is drawn to the circle from the direction in which the wind is coming. This indicates the wind direction Velocity is indicated by "feathers" on the end of the line, as shown in the table on page 49 A short "feather" equals 1 and a long "feather" equals 2 on the standard wind scale. Two long and one short "feather" would equal 5 and so on. There are twelve standard wind velocities on the Beaufort wind scale.

WIND PRESSURE —You know that it is difficult to walk against a strong wind This difficulty in walking is caused by a characteristic of wind which is called *wind pressure*. Wind pressure changes in proportion to the square of its velocity. For example, if a wind of 5 miles per hour increases to 10 miles per hour, the wind pressure becomes four times as great as it was formerly. Here is how such a change in wind pressure is worked out. The square of 5 is 25 (5×5). The square of 10 is 100 (10×10). One hundred is four times as great as twenty-five.

FIELD RESEARCH

A wind blowing 10 miles per hour exerts pressure of about 0.27 pound per square foot. What would be the total pressure on a window of your school or house? (Height and width × 0.27 pound.)

GENERAL PROBLEM 6

What Is the Humidity of the Air?

MOISTURE IN THE AIR.—You know that the moisture in the air is really water. Usually it is in the form of an *invisible* gas. It is referred to as the *humidity* of the air. The invisible moisture is the gaseous state of water. You have, however, *seen* fogs, clouds, and rains. Thus you have had first-hand evidence of the presence of those forms of moisture in air. The amount of gaseous moisture in the air varies from time to time. The air very rarely, if ever, is *saturated* with moisture; that is, it rarely contains all the moisture it can hold. The actual amount of moisture required to saturate the air depends upon the temperature of the air.

Warm air can absorb more moisture than cold air. The amount of moisture in the air at any one time is always *relative* to the amount which the air would hold if completely saturated at the same temperature. For example, if the air contains three fourths as much moisture as it could possibly hold at a given temperature, the *relative humidity* is 75 per cent.

HYGROMETER.—*Hygrometer* is the name of the instrument used to measure the relative amount of moisture in the air. It usually consists of two thermometers. The bulb of one thermometer is dry. The bulb of the other thermometer is covered with a wick which dips into water. The wick soaks up water and wets the bulb. The liquid water on the bulb changes into gaseous water (evaporates) and escapes.

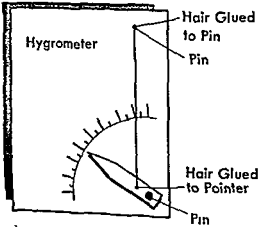
As the water on the bulb changes from the liquid state to the gas state, it absorbs heat from the mercury in the bulb. This causes the liquid in the bulb to contract. The other thermometer bulb, which is kept dry, indicates the real air temperature.

The evaporation of water from the wet bulb absorbs heat from the mercury in that bulb Thus it reads lower than the actual air temperature as shown by the dry bulb thermometer. The drier the air, the greater will be the difference in readings between the wet bulb and the dry bulb. This is because, in the drier air, the water on the wet bulb will evaporate faster and therefore absorb heat faster from the mercury. If the air could be saturated with moisture, no water could evaporate from the wet bulb Then the wet bulb and dry bulb would read alike, and the relative humidity would be 100 per cent.

Now we can see how the humidity of the air affects our comfort When the relative humidity is low, perspiration on our skin evaporates rapidly, cooling the skin. When the relative humidity is high, the air contains much moisture. Perspiration cannot evaporate rapidly, and the skin is not cooled.

Experiments 7 and 8 deal with relative humidity.

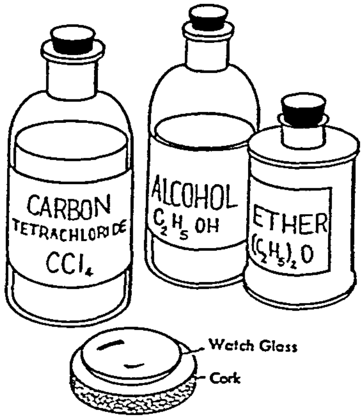
FIELD PROBLEM



Make a hygrometer using a length of human hair. The amount of moisture in the air affects the length of hair. First soak a long length of hair in carbon tetrachloride to remove any oil Then make the hygrometer, using the diagram as a guide Attach the hair to the pointer very near the pin holding the pointer Make the pointer of cardboard just heavy enough to hold the hair taut You can calibrate your hygrometer by obtaining several readings on different days from a commercial hygrometer.

EXPERIMENT 7

Does an evaporating liquid absorb heat?



The caution says not to have any flame about while you do this experiment. This is because two of the liquids catch fire easily. Which two?

Be careful when pouring the liquids into the watch glasses not to spill any. Someone with a steady hand should do the pouring, with the watch glass close to the neck of the bottle.

Do you think you could use water instead of any of these liquids and show the same thing? Try it.

WHAT TO USE.—Alcohol; carbon tetrachloride; ether; a large flat cork; a small watch glass and a little water.

CAUTION: Do not have any flame or fire near by.

WHAT TO DO.—1. Put a few drops of alcohol on the back of your hand and let it evaporate.

2. Repeat, using a few drops of carbon tetrachloride or ether.

3. Place a few drops of water on the cork. Set the watch glass in the water and fill it with ether. Fan the ether briskly.

WHAT HAPPENS.—1. Did the alcohol on your hand dry up (evaporate)? Did this make your skin feel cold?

2. How did the other liquids act when used in the same way?

3. Did the ether in the watch glass evaporate? Did fanning make it evaporate faster? What happened to the water under the glass?

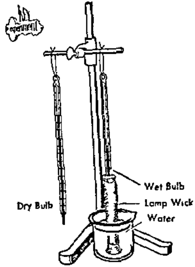
CONCLUSION.—Do liquids absorb heat when evaporating? Explain.

APPLICATION.—Why does fanning make you feel cooler? Why is it colder in a wind than out of the wind?

A LAW.—When any liquid evaporates (turns to the gaseous state), it takes in or absorbs heat.

(KEY) EXPERIMENT 8

What is the relative humidity of the air?



In this experiment you will use the principle you discovered in Experiment 7 Can you repeat that principle?

If you do not have two thermometers, you can get along with just one, although not as conveniently If you have only one thermometer, use it first to get the air temperature before wetting the bulb. Then put on the wick and use it as a "wet bulb" thermometer.

If you should use ether instead of water to wet the wick, would the mercury in the thermometer be higher or lower than when water is used?

WHAT TO USE —Two thermometers, a ring stand, a lamp wick; and a beaker of water

WHAT TO DO —Place the wick on one of the thermometers, supported so that the wick will hang in the beaker of water as in the drawing.

Hang the second thermometer alongside the first, as in the drawing.

If you observe closely, you will see that the bulb of the thermometer with the wick on it is wet all the time. This is called the "wet bulb" The other bulb that is dry all the time is called the "dry bulb."

Allow the apparatus to stand a few minutes, and then fan both bulbs. Record the temperature of the air shown by the dry-bulb thermometer. Record the temperature shown by the wet-bulb thermometer.

WHAT HAPPENS —Does the wet-bulb thermometer register lower than the dry bulb? What causes the difference?

Use the table of relative humidity in the Appendix to calculate the relative humidity. The directions will tell you how to use the dry bulb and wet bulb readings. These you should repeat in your own words in your written report.

Conclusion.—What did you find the relative humidity to be? What principle or law is involved in your finding?

Application.—What is the relation between health and relative humidity? Between relative humidity and wet things drying?

GENERAL PROBLEM 7

What Causes Precipitation?

Dew and Frost.—As the sun drops below the horizon, the land begins to cool rapidly. When the air touches the cold earth, it too becomes cooler. The water vapor which the air contains is then condensed. It forms little particles of water on cold objects, such as sticks, leaves of plants, and blades of grass. This *condensed moisture* on the cold objects is called *dew*. You may have shown by experiment in earlier science work how moisture will condense.

Certainly you have seen dew that has formed on pitchers of ice water or on blades of grass.

Warm air holds more invisible water than cold air. But if the air becomes cold enough, some moisture must separate from the warm air and become visible. When water separates from air and falls as rain, snow, sleet, hail, or forms dew or frost, the process is called *precipitation*.

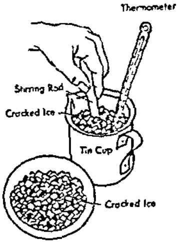
The formation of dew is illustrated by Experiment 9. If you have a thermometer at home that will not be harmed by putting it into water, you can do this experiment at home.

If, during the night, the temperature of the earth and the air touching it drops down to 32° F. or below, *frost* is formed. Frost is not frozen dew. Frost is formed when the moisture freezes as fast as it separates from the air. This results in ice crystals we call frost.

Clouds and Fog.—Clouds are known to all of us. You will understand clouds, fog, rain, and snow better if you know what clouds are and how they are formed.

EXPERIMENT 9

How does dew form?



In Experiments 7 and 8 you made use of the principle that when liquids evaporate, they absorb heat. This might be stated by saying that when heat is added to liquids, they evaporate. In this experiment, the principle of condensation is used. What is this principle?

What other experiment have you done that uses ice for the same purpose as in this experiment?

WHAT TO USE.—A tin cup, cracked ice, a stirring rod, and a thermometer.

WHAT TO DO.—1. Partly fill the cup with water at air or room temperature. Put the thermometer bulb in the water. Add ice, a little at a time, stirring constantly with the stirring rod. Do not stir with the thermometer. Why?

2. Watch the outside of the tin to note the first appearance of a film of moisture on the tin surface. At that instant read the temperature of the water.

Repeat the experiment three times.

WHAT HAPPENS.—1. Did the ice melt? Did the temperature of the water become lower? What caused it to get colder? Why did the temperature not show 32° as in Experiment 4?

2. Did moisture form on the outside of the cup? At what temperature each time? Was the water at the same temperature each time when the moisture formed?

What was the average temperature for the three trials?

Where did the moisture come from?

What was the temperature of the layer of air touching the tin dish when its moisture condensed?

CONCLUSION.—The air temperature at which its moisture condenses is called its *dew point*. What was the dew point of the air during your experiment?

What was the advantage of making three trials?

APPLICATION.—What makes the cold water pipe or water pitcher "sweat" some days in summer more than on other days?

Why do windows in the house "steam" some days and not other days?

You have learned that clouds are really particles of water that left the earth because of evaporation.

It is strange, but true, that water vapor in the air will not readily change from a gas to a liquid unless it has something to condense "on." In the formation of dew, the moisture condenses on a cold dish, a window, a leaf, or even the ground.

In the air tiny dust particles act as so many cold objects on which the water of the air can collect as little drops. Some

Fog.—This picture shows clearly that fog is low-lying cloud. What causes a fog such as this? What will cause the fog to disappear? How would this fog appear to a person walking along one of the streets?

Ewing Galloway

U. S. Weather Bureau — Science Service

Nature's Art.—The designs on the left are made up of millions of tiny ice crystals. Patterns such as these may be formed when a film of moisture freezes on a window pane. The dew drops on the rose tell us that the rose was colder than the surrounding air. Now complete the story of how the drops were formed.

scientists think that charges of electricity in the air, called *electrons*, also may act as tiny objects for condensation. Clouds consist of millions of tiny drops of water. They may be only about one thousandth of an inch in diameter. They are so light that they are held up by the air. When these masses of tiny water particles float high above the earth, we call them clouds. When they rest near the earth's surface, we call them *fogs*. The only difference between a cloud and a fog is whether it is high in the sky, or near the earth.

Two things are necessary, then, to form a cloud or a fog. Warm moist air must be cooled. And there must be something for the moisture to condense on.

Birth of a Raindrop.—Once the water particles are formed, they may grow larger. More and more water may condense on their surfaces. Finally they may become large enough to fall as rain.

A raindrop may be half a million times larger than a cloud particle. Some raindrops may be as small as one fiftieth of an inch. Others may be as large as one fifth of an inch. Raindrops fall more than 10 feet in a second. One inch of rainfall amounts to over 100 tons of water per acre.

Drizzle consists of particles of water that are less than one fiftieth of an inch in diameter. They are so small they seem to float along in the air and fall very slowly.

FIELD RESEARCH

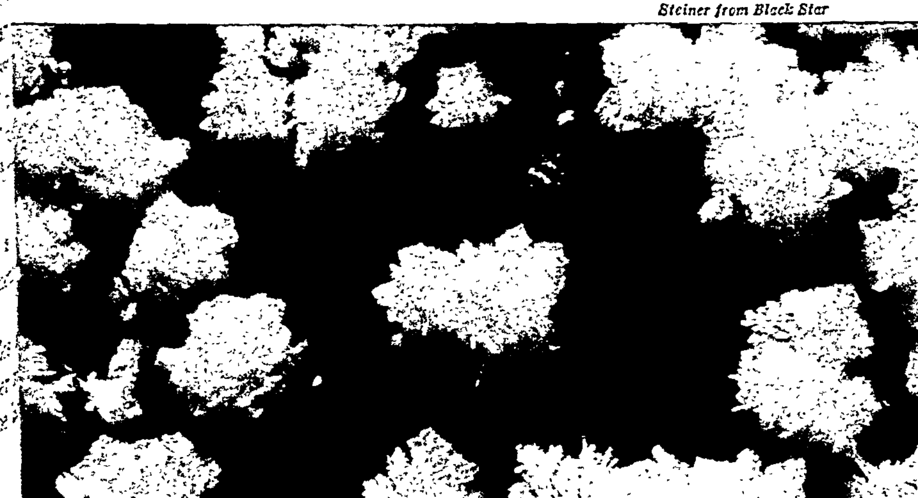
1. Make a fog in a milk bottle. Fill the bottle with hot water. Let it stand for a few minutes. Pour out all the water except for about two inches. Set an ice cube on the top of the bottle. Observe the formation of fog in the bottle. Explain how the fog formed.

2. With the aid of a large glass bottle with a one-hole rubber stopper, a glass exit tube, an exhaust air pump, a heavy-walled rubber tube and some chalk dust, try forming a fog. The air in the bottle may be cooled by quickly taking out air by means of the exhaust pump, which causes rapid expansion of the air left in the bottle. If the air in the bottle contains dust when the air is suddenly cooled as above, a fog will form. If there is no dust, put in some chalk dust and exhaust again.

RAIN-MAKING.—During the past five years scientists have been experimenting with rain-making and rain prevention.

Snow Flowers.—It would be hard to guess exactly what these unusual blossoms are. The picture is a close-up of snowflakes which have just fallen on ice.

Steiner from Black Star



Some scientists had the idea that often rain would not form because there were not enough particles in the clouds. If they could add more particles, there would be something for the moisture to condense on. Then drops would form, and it would rain.

Thus scientists got the idea of "seeding" clouds. There are two ways of seeding clouds

1. By using an airplane to sprinkle tiny bits of dry ice throughout the cloud

2 By sending up a special kind of smoke from smoke generators on the ground. This smoke is usually tiny bits of the chemical *silver iodide.*

Are these really useful ways of making rain? Scientists do not agree on the answer as yet Some scientists say that if there is enough moisture in the clouds, and if other conditions are right, seeding will produce rain Other scientists say that it would have rained anyway

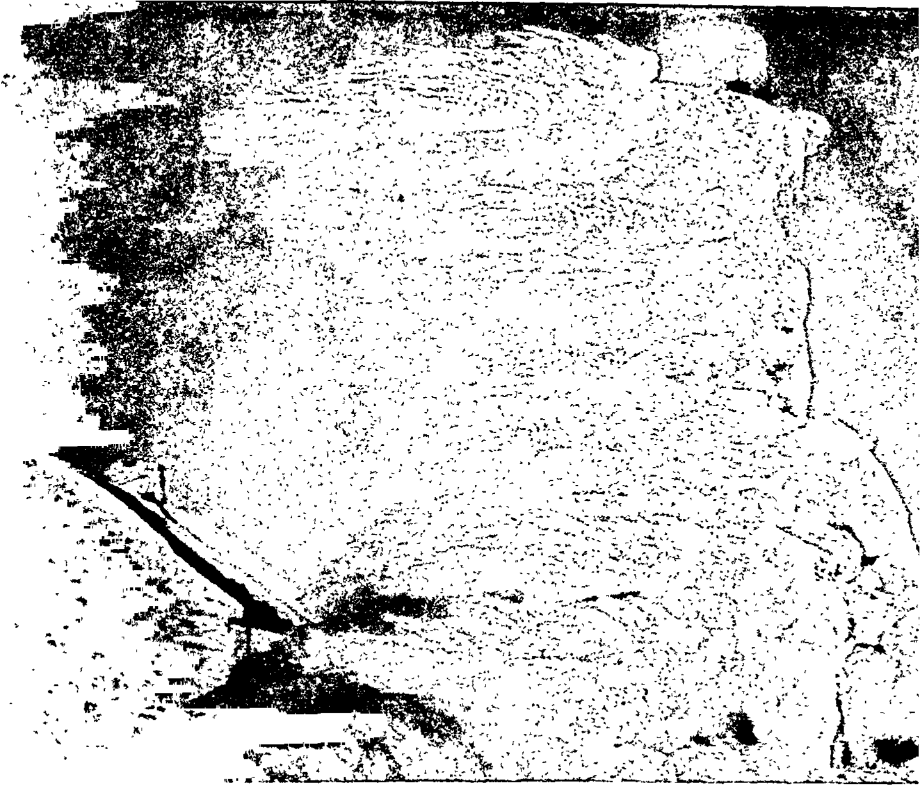
Even though it has not been completely proved yet, there are several "rain-making" companies Most of them are in the west where there are frequent droughts. However, in 1950, New York City hired some rain-makers Rain did fall on the New York City watershed. But no one knows whether the rain would have come even if the rain-makers had not gone to work!

Preventing Rain.—The idea of seeding clouds can also be used to keep clouds in the sky and to prevent rain. Often a heavy bank of clouds will prevent a frost from forming. Clouds over hot wheat fields will also help keep the soil from losing too much moisture.

For cloud-making and rain-preventing, the air is overseeded. So many particles are put in the cloud that no one particle can get enough moisture to become large enough to fall. Thus many tiny droplets are formed, but no rain.

It will be interesting to follow the reports of the rain-makers and rain-preventers. Perhaps this will be one of the greatest discoveries of the century. One scientist has already said that it is more important than atomic energy. On the other hand, further experiments may show that rain-making is not practical.

Certainly, if rain-making and rain-preventing should be-



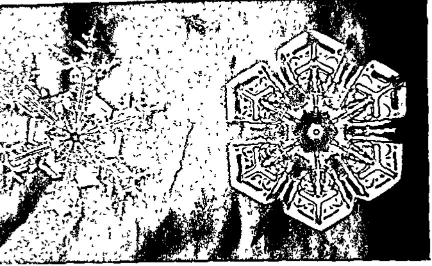
Harold Orne

Frost Feathers.—The wind atop Mount Washington, New Hampshire, has blown these frost crystals into a fantastic yet beautiful formation. The instrument at the top of the picture is used to record the amount of heat from the sun.

come common, we shall need new laws. Otherwise, some people might get too much rain, and others not enough!

Why Is the Air Cold at Higher Altitude?—In order to complete our knowledge of how it rains, we must review what makes the air above the earth get cooler as it rises.

When a gas is compressed into a smaller space, it gets hot. You remember that temperature really has to do with how fast molecules move about. When a gas is squeezed into a smaller space, the molecules are squeezed together and move faster. This makes the gas get warmer. On the other hand, when a gas expands, it gets cooler. (Refer to the Field Research on page 59.) When the molecules are allowed more room, they use up some heat and so the gas gets cooler.



Winter's Designs.—Snowflakes (left) are water crystals Can you explain that statement? The crystals are always six-sided, and no two have ever been found that are alike. How do snowflakes differ from sleet crystals (right)?

Remember, then, that gases become heated when they are compressed, and cooler when they expand This helps to explain the cooling of air at increasing altitudes above the earth

Another thing to remember is that the air gets most of its heat from the earth. Air is not heated directly from the sun. Therefore it is reasonable to expect that air farther from the earth will be colder than air nearer the earth As you know, heat from the sun warms the earth, but it does not heat the air through which it passes very much

Effect of Rising Air.—Warm air expands as it rises above the earth, therefore it cools. If the rising current of warm air contains considerable moisture, the moisture will be cooled and condense to form a cloud That is just what causes cumulus clouds

If the expansion is great enough, the cooling may result in the formation of drops of water large enough to fall. The large drops fall in spite of the rising current which keeps the smaller cloud drops dancing in the air When a gentle drizzle takes place, it shows that the rising current of air is so slow that even tiny drops can break away from their clouds and fall down through the air.

SNOW AND SLEET.—A blanket of snow is made up of snowflakes, just as rain is made up of raindrops. But is the snow that falls always the same? If you ever made a snow man or a snow fort, or if you are a skier, you know how differently snow packs. Sometimes it is so dry it will not pack at all. Then sometimes it is so wet it makes the best of snowballs.

FIELD RESEARCH

On a cold, crisp day examine snowflakes with a magnifier. You will marvel at their beauty. Wilson A. Bentley, in Jericho, Vermont, photographed thousands of snowflakes and maintained that there are no two alike.

Whenever the air is cooled to a temperature of 32° F., or somewhat lower, its moisture will freeze into tiny crystals.

Sleet Storm.—This is what happens when rain freezes as it reaches the ground. How can you explain that rain falls as liquid water and freezes as it lands? How does a storm such as this differ from a hail storm?

Courtesy National Youth Administration

More crystals form on the first crystal, and so a snowflake is built up

Snow is measured by finding its average depth, but as "precipitation" it is reported in inches of water obtained when it is melted Some snow is heavier than other snow because it contains less air, in other words, it is more packed. It usually takes about twelve inches of snow to make one inch of water.

Some people think that snow is frozen raindrops. That is not the case Frozen raindrops form what is known as *sleet*. Sleet is also formed when snowflakes melt in the air and become frozen again Even though sleet consists of little ice particles, these ice particles differ from hail in their structure and manner of formation

How Hail Is Formed.—Snow and sleet occur in the winter. Hail almost always occurs in warm weather. Hail often comes with thunderstorms It is formed by raindrops being tossed high into the air by the upward currents of air. At the high altitude the air temperature is below freezing. There the drops freeze into little balls of ice. If the hail drops, it may melt before it reaches the earth Or it may become covered with an additional layer of water condensed on its surface. If it is hurled up again, a new layer of ice will form on it In this way a hailstone is made up of layers of ice When it gets too heavy for the rising currents to keep it up, it falls to earth.

Thinking Things Over.—There are many weather factors you must know before you can get a really good idea of what weather is. These factors are all closely related to each other. Therefore, a change in one weather factor affects most of the others.

When you realize the importance of each weather factor and the need to observe or measure it, you can understand why animals cannot be good weather forecasters. Predicting the weather is a job for scientists.

Our next few problems will deal with storms and weather forecasting You will need to apply what you know about weather factors. If you are doubtful about your understanding of the weather factors that have been discussed, make a quick review right now.

Key Words

air mass
air pressure
altitude
aneroid
atmosphere
Centigrade
clinical
clouds
cold front
contract
cyclone
dew
electron
evaporate
Fahrenheit
"fixed points"
fog
frost
hail
humidity
hygrometer
mercury
millibar
precipitation
rain
rain-making
relative humidity
saturated
sleet
snow
temperature
thermometer
tornado
Torricelli
velocity
warm front
wind

Key Statements

1. Our senses are poor indicators of temperature.
2. Metals expand at different rates.
3. Mercury and alcohol are used in thermometers because they expand uniformly and because their freezing points and boiling points occur at convenient temperatures.
4. Most solids (including metals), liquids, and gases expand when heated and contract when cooled.
5. The Fahrenheit thermometer scale has 32° for the temperature of freezing water (or melting ice) and 212° for the boiling point of water at sea-level air pressure.
6. The Centigrade thermometer scale has 0° for the temperature or freezing water (or melting ice) and 100° for the boiling point of water at sea-level air pressure.
7. Air pressure (atmospheric pressure) is due to weight of the air.
8. The air pressure decreases as the altitude increases.
9. Air pressure can be measured with a barometer.
10. Wind is caused by the unequal heating of the air.
11. Great masses of air move across the country from cold regions to warm regions or from warm regions to cold regions.
12. The front edge of the cold mass of air is called a *cold front*. The front edge of a warm mass of air is the *warm front*.
13. Sometimes when a warm front meets a cold front, a counter-clockwise whirl of air is produced. These great air whirls are called cyclones.
14. The pressure of the wind increases as the square of its velocity.

15. Relative humidity is the ratio of the amount of moisture in the air to the amount that would be needed to saturate the air at a given temperature

16 Evaporating liquids absorb heat

17 Dew forms by condensation of the moisture of the air by contact with cold objects Frost occurs if the cold object is below freezing

18 Rain results from the condensation of the water particles on dust or electric charges

19 Rising air currents expand and become cooler

20 Snow is composed of ice crystals formed by the freezing of the moisture of the air

21 Sleet forms from the freezing of raindrops.

22 Hail is made up of little balls of ice in layers.

Thought Questions

1 What happens when milk in a bottle freezes? Why does freezing water break up rocks?

2 Why does not an alcohol thermometer have temperatures marked as high as 212° F ?

3 Why are the freezing point and the boiling point of water taken as "fixed" points on thermometers?

4 Why does the mercury stay up in the tube of a barometer?

5 How can a barometer be used to determine altitudes?

6 Why must the top of a barometer tube be sealed?

7 Why is it necessary to remove some of the air from the box of an aneroid barometer?

8 Why does the wind blow?

9 Why will sprinkling a street with water cool the air?

10. Why is dew or frost less likely to form on a cloudy night than on a clear night? Or under a tree than in the open?

11 Why do we use more gasoline to drive a given distance at 60 miles an hour than at 40?

12. When would the wet bulb and dry bulb thermometers of a hygrometer read the same?

13 What is the relation between relative humidity and comfort?

14 Explain why snowflakes are made of crystals and hail is not.

Projects for Your Science Discovery Book

1. List all the uses of thermometers you can discover

2 Record the extreme temperatures for your town Do you be-

lieve that summers are cooler and winters warmer than they used to be? Investigate by means of weather bureau reports to find the facts.

3. Keep a daily weather record for two weeks. Make observations at the same time each day. Include reports of wind direction and velocity, temperature, precipitation, and cloudiness.

4. Keep a special record of wind direction for one month to determine the prevailing wind direction of your locality.

5. Make a report on the direction and effects of ocean currents.

6. Make an air thermometer and compare it with a house thermometer.

7. Using Magdeburg hemispheres and an exhaust air pump, prove that the atmosphere exerts a pressure.

8. Make an anemometer (wind meter).

9. Make a wind vane.

10. Make a hygrometer and use it to determine the relative humidity of the air.

11. Find out why water is not a suitable liquid to use in a barometer.

12. *To show air pressure, place a pint of water in a gallon tin can* and heat the water so that the steam will drive out most of the air. Discontinue the heat and close the opening of the can so that it is air tight. Pour cold water over the can to condense the steam. What happens? Explain.

13. Dissolve 10 grams of cobalt chloride in 100 cc. of water. Soak small strips of cloth in the solution. Remove them and let them dry thoroughly. Mount the strips so that they hang in the air. Notice the color change with changing humidity of the air.

14. List some of the problems of high altitude flying. For example, problems of intense cold, problems of low air pressure.

A. Devaney Inc.

Winter Fury.—A blizzard like this forces man and beast to find shelter. With the temperature down to zero or below, the wind may whip the snow into twenty-foot drifts.

TOPIC III

Storm Areas

DO YOU KNOW—

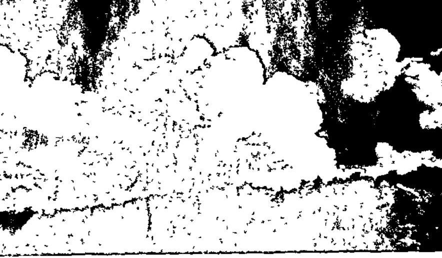
1. What lightning is?
2. What makes thunder?
3. Whether lightning ever strikes the same place twice?
4. What a thunderhead is?
5. How to tell when a cold front passes?

GENERAL PROBLEM 1

What Are Local Storms?

LOCAL WEATHER.—When the weather man predicts rain and the day continues fair, do you laugh at the mistake and say, "That is another weather joke"? Or do you realize that the prediction referred to a much larger area perhaps than your home town? Sometimes the mistake is due to the "train being late." Railroad trains run on schedule, and yet they are late once in a while. So it is with the weather. Born maybe in the far north, the Pacific Ocean, or Gulf of Mexico, storms move across the United States in fairly well-defined paths. But the speed of storms does not depend upon a well-controlled engine. Rather, storms follow the laws of nature. And nature doesn't always work on an exact time schedule.

So it is that storms may be late or early. The "weather," as it moves along, is affected by many local conditions. Mountains, hills, valleys, deserts, lakes, forests, amount of sunshine all affect the air temperatures and moisture. In other words,



Thunderhead—As more and more moisture condenses, the fair-weather, cumulus clouds change into thunderheads. Very soon now one may expect to hear thunder rumbling in the distance.

they affect the weather So, even though the forecast may be "fair and warmer," sometimes your locality will have thunderstorms or other local storms.

THUNDERSTORMS.—The thunderstorm is one of the most interesting of local storms What causes a thunderstorm? If moist air is lifted fast enough and far enough, a thunderstorm results.

Weather scientists believe that the air is usually lifted in one of two ways

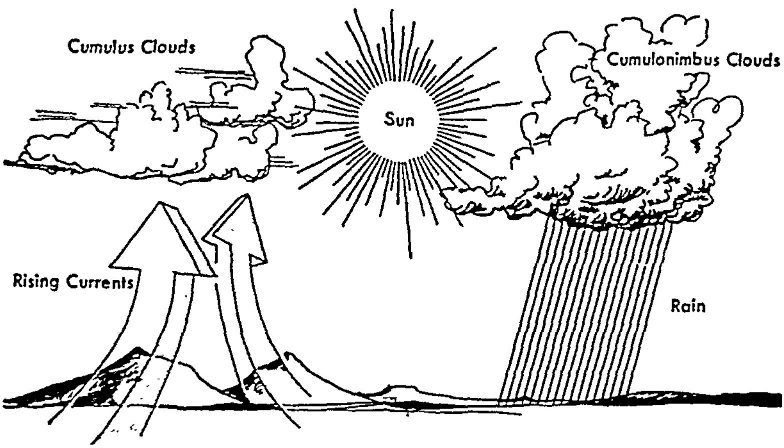
1. *Frontal thunderstorms.* A cold air mass pushes in under a warm air mass The warm air mass is forced up. We read about this when we studied winds. See the diagram on page 46.

2. *Air mass thunderstorms.* A mass of air is heated so hot that it rises due to the air crowding in on all sides. See the diagram on page 71.

In either type of thunderstorm, you know that the rain which falls is cold. In fact, sometimes hail occurs. This tells us that a thundershower is caused by a very sudden and severe cooling of the air above the earth.

You can tell whether a thunderstorm was the frontal or air mass type. If the air is cooler after the storm, it probably was a frontal storm. This is because the cold air mass has replaced the warm air.

An air mass thunderstorm usually occurs like this. Early in the morning the sky would be clear. Humidity would be high. Toward the middle of the morning, scattered cumulus clouds would appear. By afternoon the temperatures would be very high. The clouds would by this time have developed into great giants of *cumulonimbus*, and late in the afternoon the storm would break.



Air Mass Thunderstorm.—Can you describe the conditions that probably existed before and after this thunderstorm?

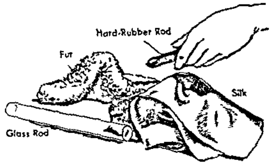
As soon as the sun sets, the storm will begin to disappear. This is because it is the sun which is warming the mass of air and causing the air mass thunderstorm. After the storm has passed, the air will be just as hot and just as humid as it was before.

Most thunderstorms are of the frontal type. These are the storms which freshen and cool the air.

The thundershower is so named because of the noise caused by lightning. It is also called an electric storm because of the electric discharges it produces. Benjamin Franklin, as you

EXPERIMENT 10

How can static electricity be made?



In all the experiments so far, you have used the energy called "heat" In this experiment you will use a different form of energy —electricity

Most of you can try this experiment at home by rubbing silk, flannel, or fur on hard rubber combs or fountain pens, and by rubbing your feet on the rug This experiment works better on a cold day when the air is dry, so if it doesn't work well one day, try it on another day.

WHAT TO USE —Pieces of fur and silk, a glass rod, a hard rubber rod; bits of paper.

WHAT TO DO —1 Rub the fur briskly on each of the rods for a moment As soon as you stop rubbing hold the rubbed end of the rod near your finger Repeat the test, using the silk with each rod.

2 Again rub each rod with the fur and silk in turn, and each time pick up small bits of paper. Notice which combination works best

WHAT HAPPENS.—1 Did you hear a slight crackling as you rubbed the rods? Did a spark occur when you held each of the charged rods near your finger? Was there a noise when the spark occurred?

2 Did the rods attract the bits of paper after being rubbed? Which combination seemed to work best?

CONCLUSION.—Did you make electricity by rubbing two substances together? Did the electricity form on the rods?

APPLICATION.—Briskly rub a cat's or dog's fur with both hands. If you feel an electric shock explain why.

remember, discovered the relationship of lightning and electricity by means of his famous kite experiment, conducted during a thunderstorm.

LIBRARY RESEARCH

Read an account of Franklin's experiment with the kite to refresh your memory.

WHAT MAKES LIGHTNING?—In order to understand about lightning, you must have some knowledge of electricity. In general, there are two kinds of electricity: *static electricity*, and *current electricity*. Later on in our study we shall discuss current electricity. Right now we are interested in static electricity. This is the kind which causes lightning. Experiments 10 and 11 will help you to know more about the subject of static electricity.

Have you ever scuffed your feet across a carpet and then touched another person? If it was a cold dry day, you may have felt a "shock." Or perhaps you saw a spark, or heard a slight snap. If you have had this experience, you already know that friction can cause static electricity.

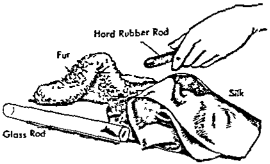
In Experiment 10, fur is used to rub on a hard rubber rod. Silk is used on a glass rod. These materials are good producers of electricity when rubbed together. Of course, many other substances could be used. If you have plastic seat covers on your automobile, perhaps you have already learned that just sliding across the seat will produce electricity! A silk lining of an overcoat rubbing against woolen trousers will produce electricity.

The rubbing (friction) doesn't really *make* the electricity. Scientists believe that things are actually made up of electricity, that is, electric charges. In fact the molecules about which you have learned are made up of atoms. And atoms are made up of positive and negative particles or charges of electricity.

Ordinarily the + and − charges are equal in a body, but friction causes them to separate. That is why you have a

EXPERIMENT 10

How can static electricity be made?



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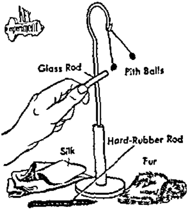
(KEY) EXPERIMENT 11

Does static electricity have more than one kind of charge?



What kind of energy is used in this experiment? What are you trying to discover that you did not discover in Experiment 10?

The force of gravity is mentioned. While it acts in some ways like electrical charges and like magnetism, it is really different from either one. Can you tell how it is different?

WHAT TO USE.—A piece of fur, a piece of silk, a glass rod, a hard rubber rod, two pith balls—one on each end of a short thread, and a support for the thread.

WHAT TO DO.—1. Hang the pith balls with the thread over the support so that the balls touch each other.

2. Rub the fur on the glass rod and at once hold the rubbed end of the rod near the balls but without touching them.

3. Repeat, only touch each ball with the glass rod (this is called charging the balls), and then keep the rod near the balls. Now bring the fur near the balls but do not touch them.

4. Again charge the balls with the glass rod rubbed with fur, and then bring the hard rubber rod, which has now been rubbed with the silk, near the balls. Now bring the silk near the balls.

WHAT HAPPENS.—1. Did the balls touch each other when hanging naturally and not influenced by anything except the pull of gravity?

2. Were the balls attracted to the glass rod at first?

3. After the balls were touched (charged) with the glass rod, were they still attracted to the rod? Did the fur attract them? Did they hang away from each other?

4. When the balls were charged from the glass rod rubbed with fur, were they attracted or repelled by the hard rubber rod rubbed with silk? By the silk?

CONCLUSION.—How many charges of electricity have you made?

How do they act toward each other? That is, do like charges repel or attract each other?

When an electric charge formed on a rod, did a different charge form on the fur and on the silk?

When glass and silk are rubbed together, one charge of electricity forms on the glass and another charge on the silk.

When glass is rubbed with fur, the glass has the same charge as the silk had when rubbed on glass. This happens too when rubber is rubbed first with silk and then with fur.

There are two charges of electricity. They are called positive and negative. Glass is charged with positive (+) when rubbed with silk and negative (−) when rubbed with fur. Hard rubber appears to act just *the opposite, negative (−) with silk and positive (+) with fur.*

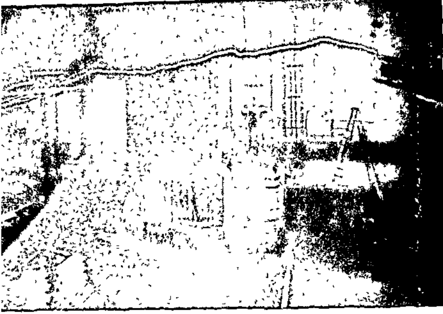
APPLICATION.—Rub a comb or a fountain pen with silk or fur. Hold it near tiny bits of paper to attract them, then if they jump away after a second or two, explain what happens.

spark. When the + and − charges are separated they try to get together again, and this they do when the spark occurs.

So it is that we have two charges or forms of electricity. The negative charges of electricity are often called *electrons.* We shall use the word electron to mean negative electricity. The positive charges of electricity are for convenience called *protons.* We shall use this word, too, in our talks about electricity.

A thundercloud is a dense mass of water particles containing electric charges. There are many theories as to how lightning is formed. According to one theory, raindrops get so big that rising currents of air split them into two unequal size drops. When this happens, it is thought that the larger drops lose electrons and so they are left with too great a number of protons. They are said to be positively charged. The smaller drops gain the electrons lost by the big drops and so they are negatively charged. If a large number of raindrops become split and then separated into two clouds by the air currents, the electric charge may jump across from one cloud to the other. This discharge is lightning.

Another explanation of lightning is as follows. Sometimes the charged particles separate so that the upper part of the



Man-made Lightning —This spark is made by a charge of electricity passing through the air Experiments of this type help scientists learn more about the nature and control of lightning. Compare the size of the instruments with the figures of the two men.

cloud is made up of the smaller negatively charged particles. The lower part of the cloud has the larger positively charged particles Then the discharge, lightning, takes place between the two parts of the same cloud.

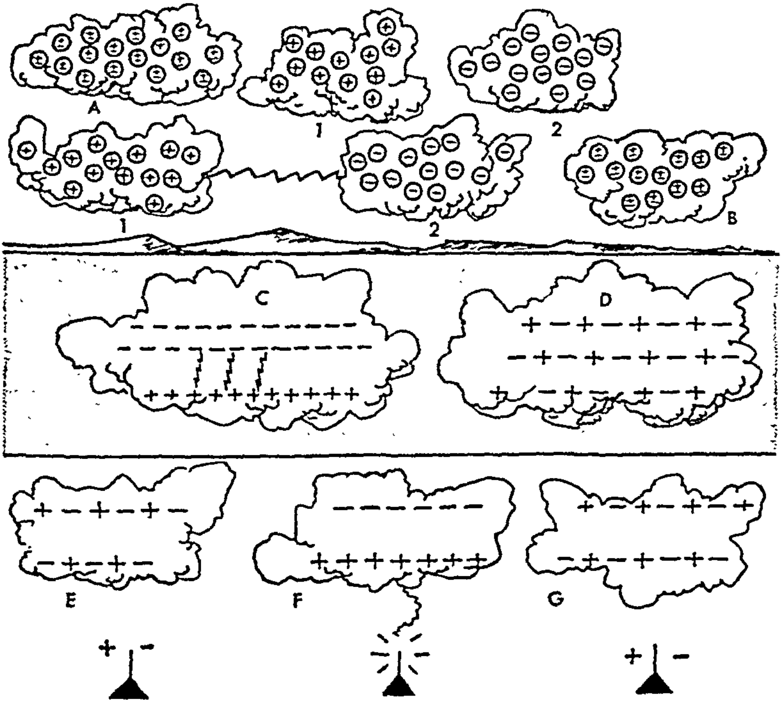
Sometimes the lightning discharges between the earth and a cloud An explanation for this appears in the diagram, page 77.

We should remember that there is still much to be discovered about lightning. Many scientists are photographing and studying lightning flashes. As they discover new facts, we shall have to change our theories.

Chain lightning occurs when the flash or discharge is from cloud to cloud The flash may be several miles long.

The tendency of unlike (positive and negative) electric charges to come together is measured in *volts*. It requires a charge of a thousand volts to jump one twenty-fifth of an inch through the air. Can you imagine, then, the enormous number of volts represented by lightning when the distance between clouds may be a mile or more?

WHAT IS THUNDER?—When the electric discharge passes through the air, it heats that air very hot. That is why you see the flash. The rapid heating of the air causes it to vibrate, resulting in sound. Just as a vibrating string sets the air vibrating in waves which reach your ear, so too lightning results in air sound waves that reach your ear. The rumbling roar of thunder has an explanation which you can think out. Start with the idea of an echo. Give your answer to the class.



Lightning Explained

Top.—Cloud A breaks into two clouds, 1 and 2, so that cloud 1 is positively charged and cloud 2 is negatively charged. After a spark of lightning jumps between the two, each cloud has an equal number of positive and negative charges (cloud B).

Middle.—In cloud C the positive and negative charges have separated so far that lightning jumps from one part of the cloud to another part. This distributes all the charges evenly again (cloud D).

Bottom.—When the positive charges in cloud F collect at the bottom of the cloud, an excess amount of negative charges are formed on the steeple. Lightning jumps, which again equalizes the charges in the cloud and on the steeple (cloud G).

IS LIGHTNING DANGEROUS?—Lightning causes damage, but few people are injured or killed by it. The greatest damage is due to fires, especially in forests. This is one of the very few causes of forest fires that man cannot prevent.

Some places seem more likely to be struck by lightning than others. For example, a barn filled with straw or hay seems more likely to be struck than a house A tree or a person in an open field are more likely to be struck than a tree or person in a wood. Hills, being nearer cloud masses, are more likely to be struck than valleys If you are caught in an open field during an electric storm, lie down Avoid lone trees

It is probably safer in the center of a room than along the walls Inside an automobile with a steel body is a safe place.

Certain it is that if you see the electric flash, you need have no fear, for that particular flash has done its work and is gone. If you count the number of seconds between the time of the flash and the sound of the thunder, you can estimate the distance of the storm. Here is a scheme for doing this:

The light of the flash reaches the eye almost instantly because light travels 186,000 miles a second The resulting sound travels

Lightning Fingers.—Skyscrapers in New York City are struck by lightning repeatedly. The buildings are made of steel Thus each building acts as a giant lightning rod The lightning stroke is carried harmlessly to the ground.

Wide World

J. W. Enger

Lightning on the Plains.—Three strokes of lightning reached the ground at the same time during a storm at Oakes, North Dakota. The electricity of one stroke ran along a wire fence, making the streaks of light as it jumped gaps in the wire.

only about one fifth of a mile a second. By slowly saying the words one thousand one, one thousand two, one thousand three, etc., you can mark off approximately as many seconds as you continue to count. By counting in this way, you can determine the number of seconds between the flashes and the thunder. This will tell you how many fifths of a mile away the storm is.

Lightning Protection.—Many devices and schemes have been invented for protection against lightning. Of them all, lightning rods are best. Lightning rods properly installed with good ground connections are a real protection to buildings. Lightning rods collect the charges from the earth and allow them to pass off into the air. This prevents too many charges from building up and attracting lightning. If, however, a discharge does take place near a building equipped with lightning rods, the charge will usually pass through the rods to the earth. Thus the building is saved from damage. It is a law of electricity that an electric current will follow the easiest path—in other words, the best *conductor*. Lightning rods and

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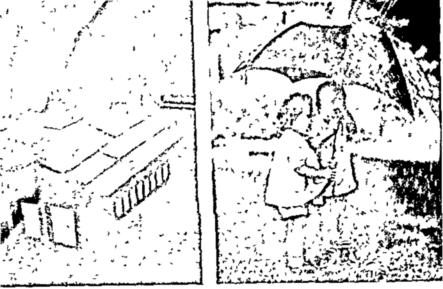


Umbrella-Type Lightning Rod—Can you see the similarity between these two "umbrellas"? The lightning-rod arrangement protects the house because lightning may strike either rod or the cross wire and thus be safely grounded.

wires connecting them to the ground are good conductors of electricity

Scientists are all the time learning more about lightning. They construct machines that will produce great discharges of electricity that imitate lightning. As they learn more about it, we shall be better able to protect ourselves and our property.

GENERAL PROBLEM 2

What Are General Storm Areas?

CYCLONES OR LOWS.—We should remember that there are both local and wide area storms. Local storms cover only a small area—a city or town, or perhaps even just a part of a city. Wide area or general storms, on the other hand, may cover thousands of square miles

The factors which cause local storms are often closely related to the more widespread or general storms. Therefore we should become familiar with the characteristics, causes, and results of general storms. We may think also of general or widespread fair weather areas.

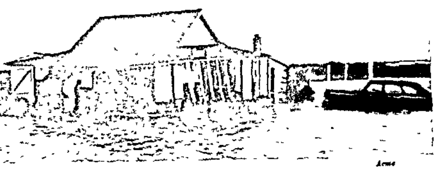
General storm and fair weather areas are often known as cyclones and anticyclones. Like most weather conditions they are the result of unequally heated areas of land. In the center of the cyclone area the air pressure is *low* because of the rapidly rising warm air. Hence they are called *lows*. Cool air rushes in from all sides to push up this expanding warm air. The warm air carries much moisture up with it. As it rises and expands and cools, condensation takes place. Often the result is precipitation.

You have learned that the air in the cyclone area is moving counter-clockwise. You should recall that the word cyclone as used here does not mean a tornado. Cyclone is the name given to a great mass of whirling air. It may be many miles across, perhaps several hundred miles in diameter. That is why it is called a general storm area.

ANTICYCLONES OR HIGHS.—"What goes up must come down" is quite true even of air. Air that is pushed up because it is lighter than other air gets cooler as it rises. It spreads out and

Dark Skies.—A billowy cumulus cloud has turned into a cumulonimbus cloud. Nimbus is a rain cloud. Rain can be seen falling from the cloud. What would cause a cumulus cloud to become a rain cloud?

U. S. Weather Bureau



Flood Waters—A storm moving over an area may drop so much rain in the region that a flood results. Then homes and belongings are left to the mercy of the flood waters.

falls back to the earth again. As this air settles toward the earth, it pushes harder on the earth than the rising air. As a result the air pressure is higher So this downward pushing air is called a *high.*

As you might expect, cold regions are the birthplaces of many masses of cold, high pressure air Highs are continually forming in the arctic regions The air in a *high* is moving in a circular clockwise direction. This is just the opposite of the air in a *low.*

As you know, when gases are compressed they tend to get warmer, just the opposite of expanding air. Air that is warming up a little does not give up its moisture So it is quite natural that this mass of air shall be a fair weather air. And so it is. The area called a *high* is generally a fair weather area.

Cross-Country Paths of Highs and Lows.—If you examine a number of weather maps, you will discover that a *low* is often followed by a *high* The air that settles in the *high* spreads out and pushes toward the center of the *low.* There it rises, cools, and settles again It is a real circulation of the air caused by unequal heating of the air in different parts of the world.

The *lows* and *highs* move in fairly well-defined paths across the country. You can see this by studying the map on page 97. They may not always follow the same paths but on the average they do. There is some advantage in this fact for the weather forecaster, as you will learn in the next topic.

Warm Fronts and Cold Fronts.—We have learned that great masses of cold air move from the north and northwest down over the United States. Great masses of warm air move from the southwest, south, and southeast toward the north and northeast. (See the diagram on page 46.) The front edge of the cold mass is called a polar or *cold front*. The front edge of the warm mass is called a tropical or *warm front*. The *highs* and *lows* are really parts of these cold and warm masses of air.

It often happens that a mass of cold air overtakes a mass of warm air. When this happens, the cold mass wedges in under the warmer air. (Again see the diagram on page 46.) Perhaps you can remember some day when the temperature dropped several degrees in just a couple of hours. That was caused by the cold front pushing in under a mass of warmer air.

When the warm masses of air come from over the ocean or Gulf of Mexico, they usually contain much moisture. Therefore, when this warm mass meets a cold mass, storms often occur resulting in winds, rain, or snow.

Most weather troubles are found along the line where cold fronts and warm fronts meet. Back of the front lines the air conditions are fairly stable.

Hot and Cold Waves.—Can you recall a long, hot, dry spell? Or perhaps a few days of continued cold? Such weather may happen behind the lines when a cold front and warm front meet and neither gives way. The two fronts just stand still. Whatever air conditions are behind the fronts last as long as the fronts hold their positions.

If the standstill happens when a cold mass has covered quite a bit of the country, it may be that the land will be colder than normal. If the warm front has moved quite a way to the north, the temperatures of some places may be a good deal warmer than normal.

Such a hot wave may linger for three or four days, or even longer. Locally the humidity sometimes becomes very high until, finally, cooling thunderstorms result.

Philip Gendreau

Tropical Climate.—This picture suggests a kind of life in the tropical regions. In what ways are the homes and clothes related to the climate?

CLIMATE.—It is natural for us to think of climate whenever we speak of weather. As in the case of weather, we all know what climate is, but we should agree upon a definition of it. *Climate is the average of weather conditions for a particular area over a long period of time.* The climate of a certain region may be dry, hot, wet, cold, windy, mild, changeable, and so on.

Special climatic conditions are required to produce the various kinds of life in the world. Tropical climates produce abundant plant and animal life. The Arctic regions produce a scarcity of both. Man seems to be the only living thing able to adapt to any of the various climates on the earth.

Our pleasures, crops, industries, and our health are all closely related to weather conditions. Understanding the weather, its causes and effects, gives man the information to help him plan and adjust to nature's laws. Our next topic, therefore, is about weather forecasting.

THINKING THINGS OVER.—In this topic we have been thinking about local storms and general storms. We know now that local storms usually affect only small areas. They may be caused by the particular conditions in that locality. Thunderstorms, for example, are seldom widespread. They result from very rapid rising and cooling of air in a rather small area.

Ewing Galloway

Life in Nature's Ice-Box.—All the cold air on the earth comes from the polar regions. Although there is little plant life in these regions, there are enough fish and other animals to support the Eskimos.

On the other hand, we know that great masses of air move across our country. These are the air masses. Some are cold. Some are warm. Some are moist. Some are dry. As warm and cold air masses meet, *lows* may be formed which bring certain weather to large areas. In back of the *front* of the air mass, great regions are covered with warm air or cold air, depending upon the particular mass. And this air determines the weather for all the land it passes over.

Thus we can understand that all our weather is made by the air. More than that, it is the movement or circulation of the air which brings us our weather. And what causes the circulation of the air? The direct and indirect cause of all our weather is the sun, which gives unequal heat to different parts of the world.

Key Words

anticyclone	general storm area	polar front
charge (electrical)	*high*	positive
climate	hot wave	proton
cold wave	lightning	static electricity
conductor	local storm area	storm paths
cyclone	*low*	thunder
electron	negative	tropical front

Key Statements

1 Local storms include electric (thunder) storms, rain, sleet, snow, hail, and windstorms

2 A general storm area includes the air conditions over a large extent of territory General storm areas move along rather definite paths across the country

3 Weather conditions in a general storm area or cyclone are rather constant as the storm moves along

4 As air rises it expands and becomes colder.

5 Thundershowers (electric storms) are caused by sudden and rapidly rising currents of warm, moist air Expansion, due to rising, causes sudden cooling of the air, condensation, and precipitation of the air moisture

6 Lightning is an electrical discharge between near-by clouds or between a cloud and the earth

7 The rapid heating of the air from an electric discharge causes it to vibrate, which results in the noise called thunder.

8 Properly installed lightning rods on buildings are a protection against lightning

9 Great masses or blocks of air move across the country The front of a cold mass is called a polar front The front of the warm mass is called a tropical front

10 Storms often occur where a tropical front meets a polar front.

11 In a cyclone area the air moves counter-clockwise in the northern hemisphere and clockwise in the southern.

12 Hot and cold waves in the northern section of the country occur when a polar front and tropical front come to a temporary standstill

13 Climate is the average of weather conditions for a particular region over a long period of time

Thought Questions

1. Why do hailstones often form during a thunderstorm?

2 What kind of cloud form becomes a thundercloud?

3. How big is a raindrop?

4 Why is a person more likely to be struck by lightning when standing in an open field than when standing in the woods?

5 What does the phrase "best conductor of electricity" mean?

6. Tall objects in the open are more likely to be struck by lightning than are short objects. Why?

7. Where do most of the masses of cold, dry air come from?

8. Where are the warm, moist air masses born?

9. Why are cold air masses usually regions of high air pressure?

10. Where in the world are general regions of rising air? Where are the regions of settling air?

11. Why do storms frequently occur where warm fronts meet cold fronts? *Are these local storms or general storms? Give reasons for your answer.*

12. What is the general direction of movement of storms across our country? What is the reason for this?

Projects for Your Science Discovery Book

1. Study U. S. Weather Maps for a two-week period and report on cyclone movements. Sample maps may be obtained for a small charge from the U. S. Weather Bureau, Washington, D.C. Many local newspapers print an official weather map daily.

2. Keep a record of the movements of cold fronts and warm fronts on daily weather maps for a two-week period. Note particularly the direction of movement.

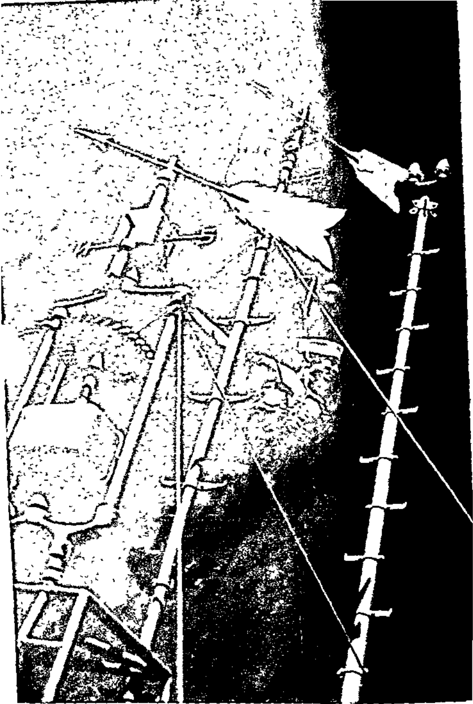
3. Make a labeled drawing of the formation of a thundercloud, studied from observation.

4. If possible, take air temperatures and relative humidity before and after a thundershower.

5. Investigate the artificial lightning experiments carried on by the General Electric Company at Pittsfield, Massachusetts.

6. Explain why sometimes in the winter you get a discharge of electricity on touching another person who has just walked across a rug or carpet.

7. Prepare a class report on the various climates of the world, including a discussion of their effects on civilization.



Official U. S. Navy Photograph

U. S. Navy Weatherman.—Captains of ships and planes must have accurate and complete forecasts. The Navy maintains weather stations on shore as well as on larger ships of the fleet.

TOPIC IV

Forecasting the Weather

DO YOU KNOW—

1. How accurate the "weather man" is?
2. How far in advance forecasts may be made?
3. Why weather forecasts are important?
4. The information needed to forecast the weather?
5. Why it is cool near a large lake in the summer?

GENERAL PROBLEM 1

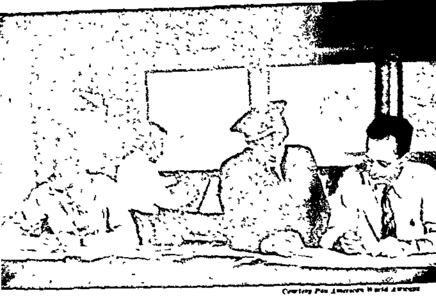
What Will the Weather Be?

Do You Believe in Signs?—The following lines were written over 100 years ago. They were learned by school children to help them "foretell" the weather.

Signs of Rain[1]

The hollow winds begin to blow,
The clouds look black,
The glass is low.
Hark how the chairs and table crack!
Old Betty's joints are on the rack.
How restless are the snorting swine!
The busy flies disturb the kine.
Puss, on the hearth, with velvet paws,
Sits wiping o'er her whiskered jaws.
My dog, so altered in his taste,
Quits mutton bones on grass to feast.
And see yon rooks—how odd their flight!
They imitate the gliding kite
And, headlong, downward seem to fall
As if they felt the piercing ball.
'Twill surely rain. I see with sorrow
Our jaunt must be put off tomorrow.

[1] From a collection of weather doggerel usually attributed to Dr. Edward Jenner and written from memory by a pupil of 1850.



Courtesy Pan American World Airways

Scientific Teamwork.—Behind every airplane flight there is scientific teamwork. Weather reports are radioed and teletyped to forecast centers where maps are made. These maps are then studied by the pilots before their planes take off.

Do you think there are any points in the poem that are true? Are there any which you think are just superstitions?

Of course you now know that weather results from natural laws. Any weather signs then must be based on natural laws if they have any truth. In any locality an observing person soon learns that a certain wind direction indicates good or bad weather. Some clouds are dark with moisture and indicate rain or, if the temperature is low, snow. Other clouds indicate fair weather. A changing air pressure shown by the barometer tells us that the weather is changing.

The flight of birds and habits of insects and small animals are believed by some to indicate changes in the weather. However, weather signs are not, for the most part, very accurate means of foretelling the weather. Most people nowadays depend more on newspaper and radio reports than on weather signs or sayings.

NEWSPAPER REPORTS.—Many newspapers print the weather reports of the United States Weather Bureau. The weather predictions are based upon: (1) a knowledge of the weather conditions all over the country; (2) exact knowledge of how general storm areas travel across the country; (3) knowledge of the air masses and their movements; and (4) the positions of the warm and cold fronts. The forecast is made for a rather large region and, therefore, is sometimes incorrect for a particular locality.

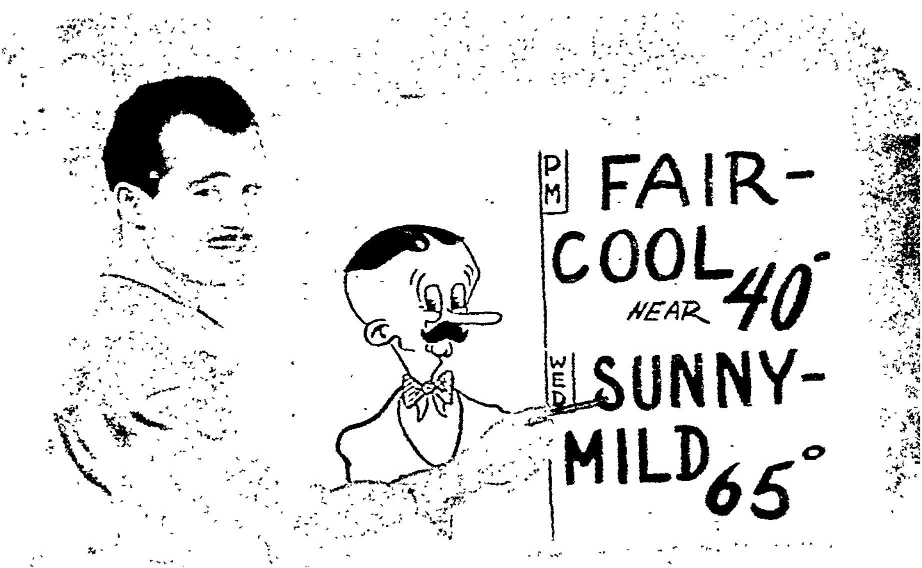
FIELD RESEARCH

Keep a record of the newspaper weather reports for one week. Opposite the forecast for each day record the actual weather. Note which weather factors are included in each report.

Radio and Television Reports.—Weather conditions and weather forecasts are made known to many people by radio or television. Most stations give a weather report several times a day. In cases of emergency, when unusual weather is about to happen, radio and television are especially important. Forewarning of the probability of violent windstorms is important to mariners. The possibility of killing frosts is important to shippers and gardeners. Airplane pilots are kept con-

Weather Forecast by Television.—Daily weather reports are broadcast by most television stations. This is how one television station helps us "see" what the weather will be.

Courtesy N.B.C.



stantly informed about weather conditions ahead. They use the reports to decide whether to proceed to their destination or make for the nearest landing field.

THE WORK OF A WEATHER PROPHET.—*Temperature, air pressure, air moisture, wind direction, and wind velocity* are factors to be considered in forecasting the weather. To foretell successfully the local weather changes, these factors must be determined very accurately. Furthermore, the observer must know how local conditions are related to the more general weather conditions.

GENERAL PROBLEM 2

How Are Official Weather Forecasts Made?

WEATHER OBSERVATION STATIONS.—There are more than 400 weather observation stations which record weather information. These stations are located in cities and towns of the United States, Alaska, in other possessions, in Canada, Mexico, and Cuba. At most of these stations, weather observers determine all the weather factors each hour.

OBSERVING THE WEATHER FACTORS.—At each weather station the observer determines the weather conditions by instruments or direct observation. Special instruments record hours of sunshine, wind velocity and direction, amount of precipitation, if any, air temperature, and relative humidity. The kinds and heights of clouds and their movements are noted, also.

Every day at 10.00 A.M. and 10.00 P.M. at about 100 stations, balloons are sent up to high altitudes. Each balloon carries instruments that send back by radio a continuous record of temperatures, pressures, and humidity. At some of these stations the travel of the balloons is followed by directional radio. Thus wind direction and velocity can be determined at high altitudes. This is important for learning about air masses. At many more stations kite balloons are sent up. They are watched by eye to determine the wind direction and velocity at different levels.

All these records tell the weather conditions not only at the earth's surface, but also up to several thousand feet. This additional information makes much more accurate forecasts possible than surface observations alone. Added to the observations by United States Weather Bureau observers are the weather reports made by air pilots during their flights.

Recently a new instrument has been used for recording weather information. *Radar* is being used to track storms and hurricanes. Radar is an electrical instrument which sends out certain types of radio waves. When these waves strike a rain squall or very dense clouds, they bound back. The radar set records the time it takes for the waves to travel out and back. Knowing how fast the waves travel, it is possible to tell how far away the storm is. Airplanes equipped with radar may be sent out to track storms and find out which way they are going.

Snowbound.—*This weather station is located on the summit of Mount Washington, in New Hampshire. What reasons can you think of for locating a weather station on top of a mountain?*

A. Devaney, Inc.

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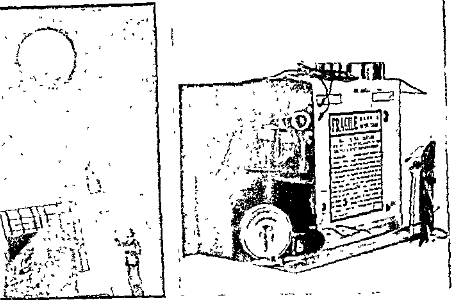


A Radiosonde Balloon.—These pictures show the balloon, parachute, and instruments An observer follows the flight with radio direction-finding device to determine upper air wind directions and speed. The box on the right contains the instruments.

Reporting to General Forecast Centers.—Once each hour the weather stations send their weather information to a General Forecast Center At present there are 17 General Forecast Centers. Some of these centers are located at Albuquerque, Chicago, Denver, Jacksonville, Kansas City, New Orleans, San Francisco, Seattle, and Washington, D. C. In addition to the General Forecast Centers, there are 21 Airway Forecast Centers. The Airway Forecast Centers are concerned with making forecasts for the airlines.

Using Code Messages —In addition to the hourly reports, weather stations send a *coded* report four times each day. The coded reports are sent at 1.30 A.M., 7 30 A.M., 1:30 P.M. and 7 30 P.M. These coded reports are very complete. If each weather condition were described in ordinary language, it would take a long message to report the weather. The use of a code makes it possible to send all the information by using num- groups A coded weather message may look like this:

40530 83220 12716 24731 67220 67228 74542

This code means:

405	is the station sending the report—Washington, D.C.
30	is the temperature of the dewpoint—30° F.
8	is the amount of cloud—completely covered.
32	is the wind direction—northwest.
20	is the wind speed in knots—20 knots.
12	is the visibility in miles—$\frac{12}{8}$ or $1\frac{1}{2}$ miles.
71	is the present weather—continuous slight snow.
6	is the past weather—rain.

The message continues in the same way. Each number or group of numbers has a definite meaning depending upon its position in the code.

THE WEATHER MAP.—Most of the larger weather observation stations make their own weather maps. They usually make a new map four times each day. This is done at the same time that they send their coded reports. The station may make a new map every hour if the weather conditions are changing

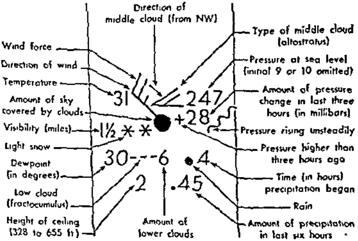
United States Weather Bureau.—Here (left) weather reports are being decoded and the information placed on maps. The man in the foreground is typing a forecast. Every six hours a new weather map is made. These maps (right) are posted in airway weather stations and in the forecast centers of the Weather Bureau.

U.S.D.A. Photograph by Hever

rapidly These maps are used for making local weather forecasts.

Four times each twenty-four hours the General Forecast Centers also make *weather maps*. These maps are used for predicting the weather for larger areas.

The weather map is a map of the United States with weather conditions written on it. These weather conditions are all the weather items you have been reading about and many others. It would take a very large map if this information were to be written out, so a "weather shorthand" has been devised. Some of the weather symbols used are shown on page 98. There are symbols for all weather conditions.



A Station Model.—Only the lines, dots, and figures in the center are put on the weather map. The explanations are given here to explain each symbol. A completed weather map will have dozens of station models like this—one for each station reporting the weather.

Often even these symbols take up too much space, so the Weather Bureau uses many of the code numbers as sent by the stations. The diagram above shows how the weather at one station is represented on the map. Each number and its position around the center dot tells something about the weather at that station.

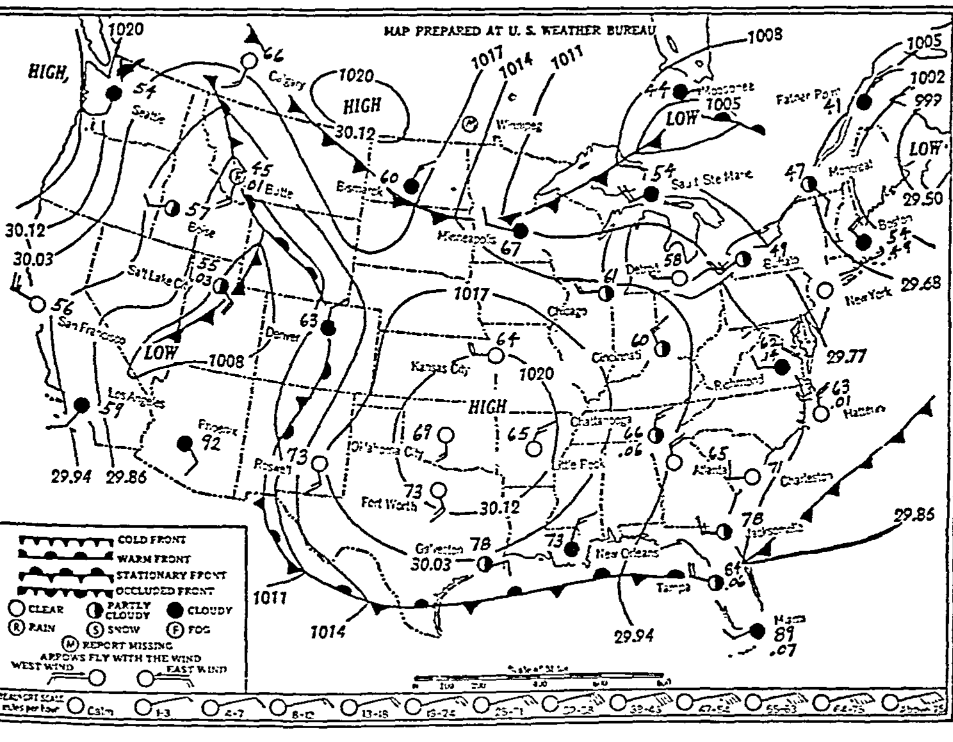
When all the weather information has been recorded, black lines are drawn through places having the same air pressure. These lines are called *isobars,* meaning equal pressure. The locations of cold fronts and warm fronts, too, are marked on the map, as well as their direction of movement. It is a marvelous map because it gives so much information. It is changed at least every six hours. During periods of unusual weather it is changed more often. You will be interested to study the copy of part of the weather map printed on page 96.

The weather forecaster studies the facts shown on the map, and from these data he forecasts or predicts the weather for the next 12 to 36 hours.

Long-Range Forecasts.—In addition to the regular forecasts, long-range forecasts are now being made. Every Tuesday and Friday, the Forecast Center at Washington makes a five-day forecast. These five-day forecasts are most helpful for fuel

A Weather Map.—This is the type of weather map which is often published by newspapers. This map does not contain all the weather information recorded by each weather station. Name the weather factors shown on this map. Find the cold front over the north-central United States.

U. S. Weather Bureau



so people may protect themselves. Fruit growers and farmers, in general, profit by taking advantage of advance information of unexpected frosts.

DISTRIBUTING WEATHER INFORMATION.—The Weather Bureau publishes a daily weather map which shows the weather conditions all over the country The weather maps may be had for a small charge by any citizen who writes for them to the nearest Weather Bureau station Thousands of postcards stating the probable weather conditions and possible occurrence of frosts and storms are sent out every day all over this great country The information on one of these cards may save thousands of dollars. In addition to these methods of distributing weather information, we must remember the use of newspapers and radio and television Many newspapers publish a weather map, weather report, and weather forecast prepared by the local weather station. Most newscasts on radio and television give the latest weather report and forecast.

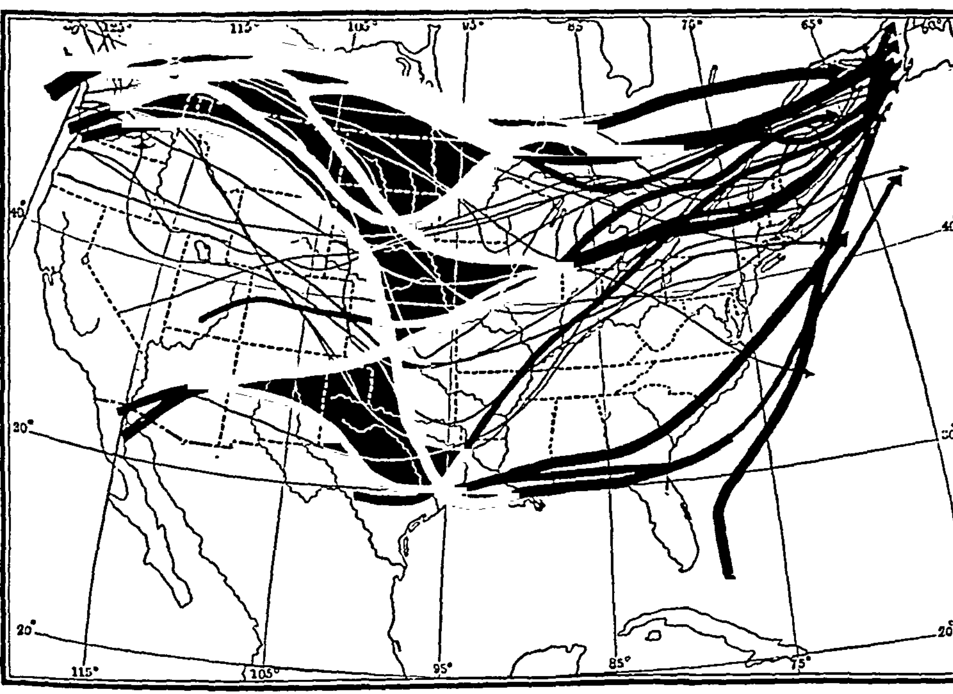
WEATHER FORECASTING AS A SCIENCE.—Accurate weather predicting is not an easy job. There are a few rules which can be used to make local weather predictions. These are stated in the Appendix of this book. If you are interested in trying your hand as a "weather man," study the rules, and then make some predictions.

One of the most important rules in weather forecasting is the fact that storms usually move across the country as shown on the map on page 101. The prediction of movement of storms is usually made according to these paths. Sometimes storms do not follow these paths. Then the prediction may be very wrong. One of the biggest storms in history fooled weather forecasters by not following the normal path This happened toward the end of November, 1950. A mass of cold air met a mass of moist warm air in the region of North and South Carolina. The masses swirled into a low pressure area, a storm center. The storm was expected to follow the normal path (see map), and move northeast and out into the ocean But there was a high pressure area to the east. This forced the storm center north and northwest. Thus the storm moved from the east coast, west to Lake Erie, and then east again. The storm brought raging winds and snow and rain to all regions within 600 miles of its center. New York City had gusts of wind over 100 miles per hour and heavy rains. Farther west the storm brought blizzards and 23 and 24 inches of snow. By the time the storm moved out to the sea it had destroyed most electric and telephone service. It had probably caused over 100 million dollars' worth of property damage.

How Accurate Are the Weather Forecasts?—Although weather forecasts are sometimes wrong, nowadays most of them are accurate. It is harder to forecast the weather in some regions than in others. Thus in southern California, where the climate is even, forecasts are about 95% accurate. In northern Michigan, however, forecasts are about 85% accurate. This is the lowest record. Forecasting the weather is difficult in this region because it is here that many of the cold air masses from Canada meet the warm moist masses from the south.

Even the thirty-day outlook forecasts are accurate 75% of the time. Thus we can understand that knowledge of the

Movement of Storms.—This map shows the average beginnings and paths of storms across the United States for the entire year. The *width of the line shows the comparative frequency of storms travelling the paths indicated.* Where do most storms start? In what direction do they move?



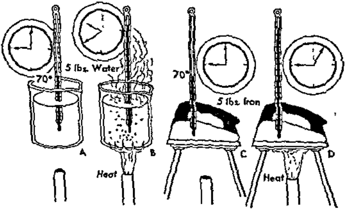
weather factors has made it possible for scientists to foretell the weather with a high degree of accuracy.

GENERAL PROBLEM 3

How Are Water and Climate Related?

WEATHER AND WATER —Water and heat are closely related in weather-making. Both must be taken into account when considering the problems of weather forecasting. When heat is added to water, the temperature of the water rises. The more water there is, the greater the amount of heat needed to cause the same rise in temperature. If enough heat is added, the water boils. Then there is no further rise in temperature as long as any liquid water remains. At boiling temperature the liquid water changes to water vapor or gas.

In nature, the energy from the sun is the source of heat for water and for the land. A soil has a certain capacity for absorbing water, a fact that every successful gardener well understands. You can see examples of this yourself, any spring or



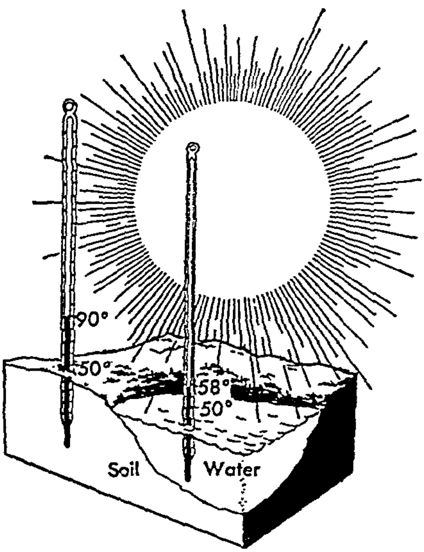
Heat Capacity —Heat capacity is the ability of a substance to absorb heat. In this diagram both the water and iron start at 70°. They are heated until their temperatures reach 212°. Which one was heated longer? Which one absorbed more heat? Which one has the greater heat capacity? Why wasn't a higher upper temperature selected instead of 212°?

summer day after a shower. In about the same way land, water, and all other substances have certain capacities for absorbing heat. In this respect, water has a greater capacity than any other common substance. This means that it takes more heat to raise a pound of water to a certain temperature than is required by the same weight of any other common substance. The rate at which a given weight of a substance heats indicates its heat-absorbing capacity. The more slowly it heats, the greater its heat capacity.

A pound of iron, a pound of brass, a pound of soil, a pound of air, or any other substance will heat faster than a pound of water if the heat is added at the same rate.

Experiment 12 is a very important one because it tells you how to discover for yourself the different effects of heating water and sand.

Temperature of Water and Soil. — When the same amount of heat falls upon water and soil, the soil heats faster. Compare the increases in temperature shown in this diagram. Does this help explain why water temperature at the lake or seashore during the day is lower than the air temperature?



THE HEATING AND COOLING OF LAND AND WATER.—Experiment 12 explains how heat affects land and large bodies of water on the earth. When the heat (energy) of the sun strikes the land, the land heats up more rapidly than near-by water. The temperature of the land becomes higher than that of the weather factors has made it possible for scientists to foretell the weather with a high degree of accuracy.

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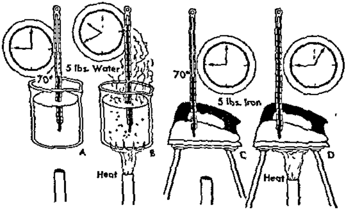

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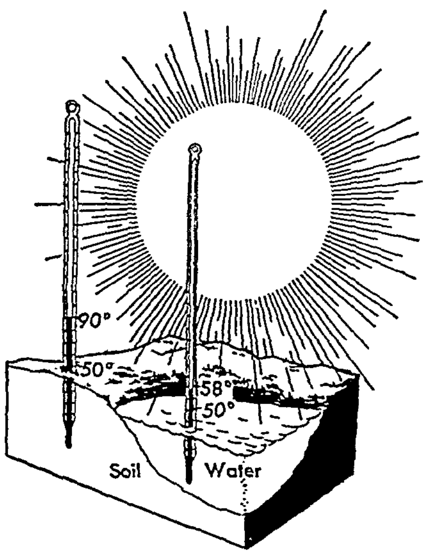

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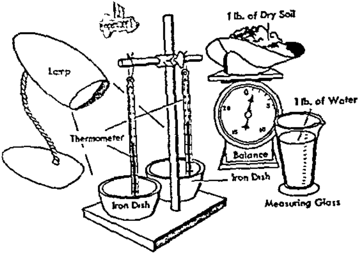
(KEY) EXPERIMENT 12

Does water have a greater or lesser heat capacity than soil?



In this experiment we use heat energy again. What is the source of the energy in the experiment? In nature?

In some other experiments and in this one you measured temperatures. What did you use? What other measurements do you make in this experiment?

WHAT TO USE.—A pound of water; a pound of dry soil, two iron or tin dishes, two thermometers, one gooseneck lamp with reflector shade and 60 watt lamp; a ring stand and clamp; a balance; and a measuring glass.

WHAT TO DO.—1. Place the pound of water in one dish and the pound of soil in the other. Set each dish on the table. Support the thermometers so that the bulb of one is in the water and the bulb of the other is in the soil.

Adjust the lamp so that the bulb is the same distance from the top of the soil and the water, about three or four inches. Turn on the electricity and heat the soil and water for fifteen minutes. Record the changes in temperature every two or three minutes.

2. Turn off the lamp and record the cooling temperatures every two or three minutes as before for fifteen minutes.

WHAT HAPPENS.—1 Did each material receive the same amount of heat? Was it radiant heat, like that from the sun?

Which material heated up the faster?

Which was hotter at the end of the fifteen minutes?

2. Which cooled off the faster when the lamp was turned off? What was the temperature at the end of fifteen minutes? Did the materials cool off as fast as they were heated up?

CONCLUSION.—Which material has the greater heat capacity? Explain.

APPLICATION.—Why is water used in automobile radiators?

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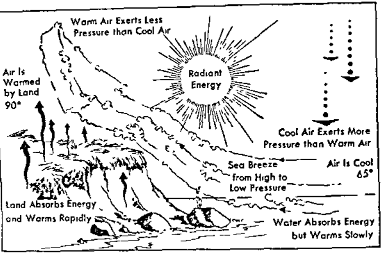
water. Study the drawing on page 103. When the sun goes down, the land cools off (loses heat) faster than the water.

These facts about the unequal heating and cooling of land and water are true not only from day to night, but from season to season. As spring advances, the land away from a large body of water becomes warmer a little faster each day than the body of water. If the body of water is large enough, the summer may be far advanced before the water becomes as warm as the land some distance away.

You know that the air is not heated directly by the energy from the sun. It must get its heat from land and water which it touches. For this reason air temperatures over the land and the water change with temperature of land and water. As the summer advances, the water of lake and sea gradually absorbs more and more heat. As fall comes on, the land away from the water quickly loses its heat. The air over the land becomes cooler. On the other hand the heat stored in water is given off very slowly, keeping the air warmer.

LAND AND SEA BREEZES.—The unequal heating and cooling of land and water causes air movements between neighboring land and water. You have learned that air currents move from places of high pressure to places of low pressure. Warm air is lighter and therefore exerts less pressure than the same volume of cold air. Another fact to consider is that air has a very low heat capacity. It therefore heats up rapidly and cools off rapidly. Still another fact to remember is that air gets its heat from the land or water. With the help of the drawings on pages 106 and 107 you are ready to explain the occurrence of land and sea breezes.



Day.—Because land and water do not heat equally fast, there are often sea breezes from bodies of water during summer days. Explain this diagram.

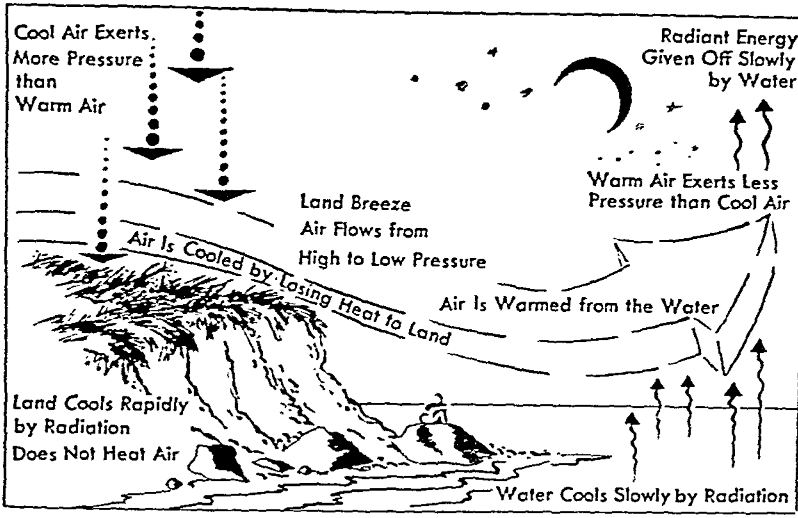
FIELD RESEARCH

Sometime when you are at the lake, with permission and caution build a small fire on the shore at night and again during the day. Do not try this experiment if there is any wind to speak of

Each time notice the direction taken by the smoke from the fire.

As the land heats up rapidly, the air touching it heats up even more rapidly It becomes lighter because it expands. At the same time the air over the cooler water continues cool. Hence it is heavier than the warm, lighter air over the land. The cool, heavier air moves from the water to the land and pushes the warm, lighter air up out of the way. The cool air, in turn, becomes warm and is pushed up by more cool air from the sea The air current thus set up is called a *sea breeze.*

At night the land becomes cool more rapidly than the water. The air over the land becomes cooler than the air over the water. In other words, the air pressure is now greater over the land than over the water. The result is an air current moving from land to the water This kind of air current is called a *land breeze.*



Night.—Unequal cooling of land and water causes land breezes at night during the summer. Explain how gravity is related to the land breeze shown in this diagram.

GENERAL PROBLEM 4

What Adaptations Are Made to Weather and Climate?

THE GROWING SEASON.—The length of a plant growing season is often determined by the number of days between the last killing frost of spring and the first one of fall. Crops that require longer time to mature than the time between these two dates are better grown where the growing season is longer.

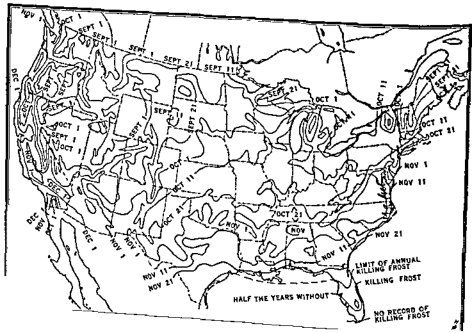
It is important for a farmer or gardener to know the length of the growing season where he lives and the crops adapted to it. It is a valuable study for us as students of science to determine what causes affect the length of a growing season in a locality.

In your investigation and discussion of the length of the growing season, you will need to consider many things. The dates of killing frosts, latitude, altitude, nearness to large bodies of water, and the length of daylight are all important. In Alaska, for example, a short growing season is made up for by long hours of daylight.

The maps on page 108 show the length of the growing season

U S Weather Bureau

Last Killing Frost of Spring (top), First Killing Frost of Autumn (bottom).—Some western growing seasons are from June to September, others from March to November. Explain.



U. S. Department of Agriculture

Flood Damage.—The warm weather of spring often brings dangerous floods. These Kansas farmers lost forty acres of corn.

in different parts of the United States. Study the maps carefully. Try to explain some of the differences.

CROPS AND RELATED INDUSTRIES.—Successful growing of certain crops requires not only special soils, but also a sufficiently long growing season. In the case of perishable crops, it is natural to expect that canning and preserving industries will be developed near by. Likewise, raising of cattle, pigs, and other livestock will develop to take advantage of products that would otherwise be wasted or shipped away. It will be a good test of your understanding if you can describe other examples of the relation of crops and industries.

WEATHER AND INDUSTRIES.—No doubt many of you can recall an occasion when the weather conditions over a large area were such that crops were completely destroyed. Such a case happened in western New York, during the spring of 1945. Early in the spring, a spell of warm weather made the apple trees blossom. Then came an unexpected cold spell, and the blossoms were killed. Without blossoms there could be no fruit.

Every year agricultural industries are very largely dependent

U S Department of Agriculture

Rugged Wheat.—This wheat was especially developed by scientists to withstand cold climates The patient work of men of science results in more and better crops for our farmers.

upon weather conditions. Every individual is concerned, because this industry furnishes our food.

Many industries depend upon weather conditions. The *canning industry*, for example, will fail unless conditions are such as to produce an abundance of *fruits* and *vegetables*. The *milling industry* will fail unless there is a sufficient amount of *wheat*, *corn*, and other *grains*.

Even such industries as the leather and clothing industries are affected by the weather Can you explain how?

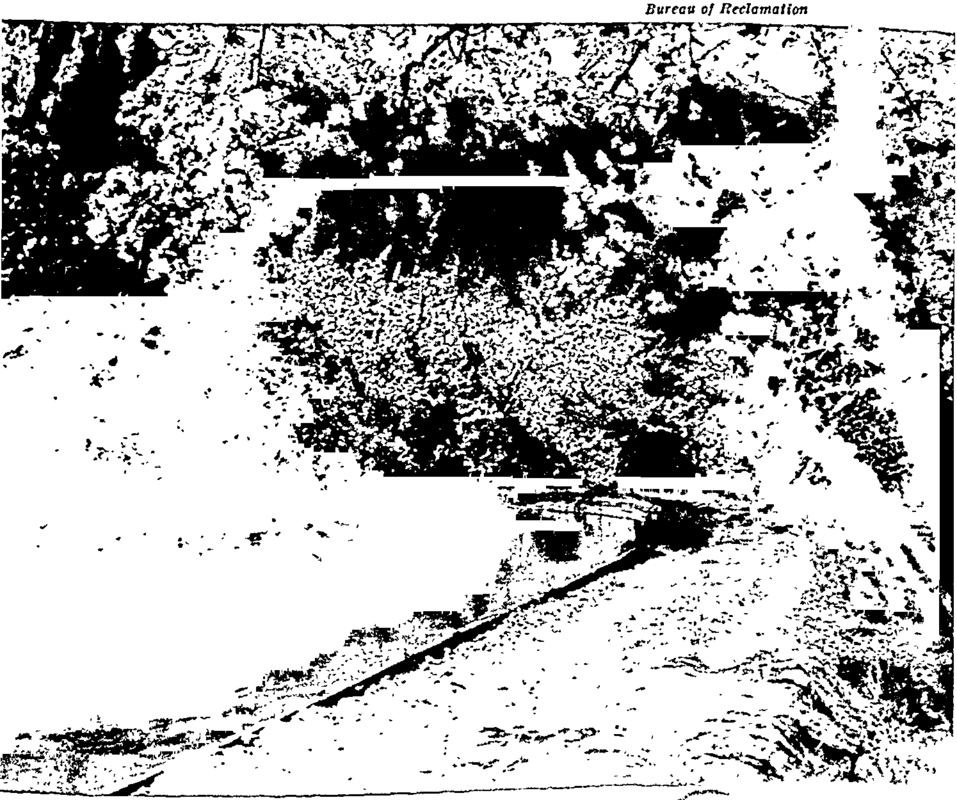
Scientific Farming.—Science has done much to help farmers and gardeners meet the problems of the weather. In the case of wheat, for example, some varieties have been developed which will withstand very cold climates Other varieties have been developed which have a shorter growing season Varieties of corn, peas, beans and other vegetables which need shorter growing seasons are also available. These are examples that show how man with increasing knowledge is able to make adaptations to natural conditions which he cannot change.

Of course, there is a limit to the adaptations which can be made. Such crops as oranges, lemons, grapefruit, and cotton cannot stand the freezing temperatures of the north. Thus these crops, and others, must be grown in the south or southwest where the climate is mild. So it happens that crops throughout the United States are grown where they are best adapted to the climate.

Practically all industries make some adaptation to weather and climate. Houses and factories are built differently in the north than in the south. Stores provide clothing adapted to the climate and season. Ways are discovered to make building easier during the winter months when work is scarce. For example, the chemist has found what to add to mortar and cement to let it set and harden without freezing. Roads are built to withstand the extremes of temperatures which occur in various parts of our country.

Modern Oasis.—This irrigation ditch is part of the Columbia Basin Project in Washington State. The project will create 17,000 small farms in land that nature left dry and unproductive.

Bureau of Reclamation

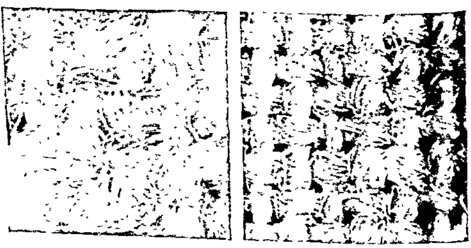


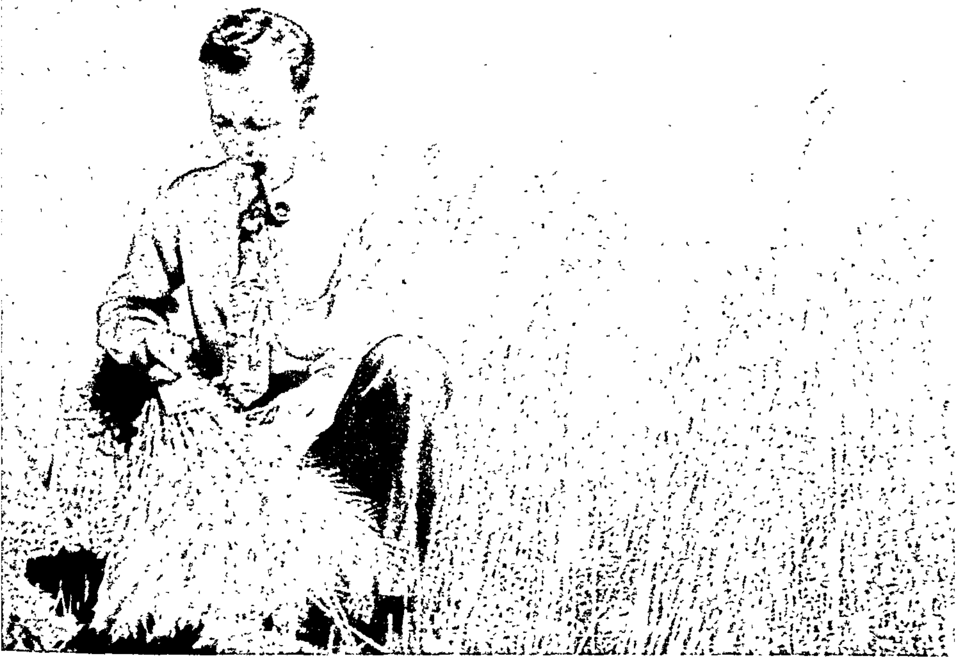
Climate and Health.—People with some diseases are able to live more comfortably and oftentimes longer in one climate than in another. On the other hand, people who are blessed with good health are able to adapt themselves to almost any kind of climate. Men accustomed to the south can, by wearing suitable clothing and eating the right kinds of food, live and work in the far north. The healthy Eskimo can adapt himself to the southern climate. However, keeping well in localities where the weather is changeable is somewhat more difficult than adapting oneself to extremes of climate.

Climate, Health, and Clothing.—To some extent, our health depends upon our ability to adapt ourselves to changes in climate or weather. Our success in adapting ourselves may depend upon our knowledge of how to control the loss of heat by the body.

Some heat is lost from the body by *radiation* just as any hot object loses heat. Any matter also loses heat by *conduction* when colder objects touch it and take heat away. When cold air touches the body, it absorbs heat. If its motion is not hindered, the warmed air is pushed away because colder air pushes in for its share of the heat. This way of taking heat away from anything by a moving or circulating gas or liquid is *convection*.

Magnified Woolen (Left) and Cotton Fabrics.—These pictures show why clothing made of wool is warmer than that made of cotton. Note that the cotton fibers are twisted together tightly and that the wool fibers are fluffy. What relation does this difference bear to the transfer of heat?





T. E. Stimson

Wheat Inspection.—Experimental wheat farms like this one help our farmers learn to overcome weather troubles.

Hotcaps.—These waxed cups protect tomatoes and cucumbers from an early spring frost in California.

Edward Sievers

So the body all the time loses heat by these three methods: radiation, conduction, and convection.

You have already learned that when liquids evaporate, they absorb heat from objects which they touch. Therefore, when the sweat of the body evaporates, it absorbs heat from the body. The water vapor thus formed mixes with the air and is carried away by the moving air currents. This explains why you feel colder in a wind than in a sheltered place on a cold day.

Controlling body heat by proper use of clothing depends upon our knowledge of how the body loses heat. Winter clothing should prevent, to some extent, the loss of heat from the body. Woolen and silk fabrics are poor conductors of heat. A woolen garment contains many air spaces among its fibers. Therefore it retards the loss of heat, because the fibers prevent the circulation of air and so convection losses are prevented. Wool also absorbs moisture and keeps it near the skin. This prevents rapid evaporation of sweat.

Summer clothing should help to remove heat from the body. Cotton and linen fabrics contain fewer air spaces than coarser woolen fabrics. Thus they allow freer air circulation, which removes heat from the body. Cotton is also a better conductor of heat than wool. So it allows heat to escape by that method, too. Cotton, linen, and silk absorb moisture and allow it to evaporate quickly. Hence these fabrics promote the loss of heat from the body by evaporation of sweat. Light colors of smooth cotton, linen, and silk also *reflect* the sun's rays. Such reflected rays do not heat the body.

You can understand now that there are scientific reasons for wearing different kinds of clothing during the winter and summer. These reasons depend upon (1) how the body loses heat, (2) how heat is transferred, and (3) the properties of different kinds of fabrics.

FIELD RESEARCH

Using a hand magnifier, examine samples of woolen, silk, linen, and cotton fabrics to discover differences in weave and air spaces.

ALCOHOL AND THE WEATHER.—Correct clothing, food, rest, and exercise are all necessary to help you adapt yourself to changing weather conditions. The use of alcoholic beverages is a handicap to successful adaptation. It may be true that small amounts of alcohol supply a slight amount of heat for the body. But it is also true that alcohol causes the blood capillaries of the skin to become larger, allowing an extra amount of blood to enter. Thus, heat loss from the body is increased. This more than offsets any heat obtained from the alcohol.

The fact that alcohol injures many body cells results in a lowering of general body efficiency. The body is therefore likely to be affected by diseases related to weather changes, such as colds and pneumonia. Alcohol is a habit-forming, narcotic drug. Like other narcotic drugs it should be used only when prescribed by a competent doctor.

THINKING THINGS OVER.—Weather forecasting is becoming almost an exact science. As such we may expect forecasts to be more and more reliable. Even now, short-range forecasts are about 90% accurate. Long-range forecasts are accurate about 75% of the time.

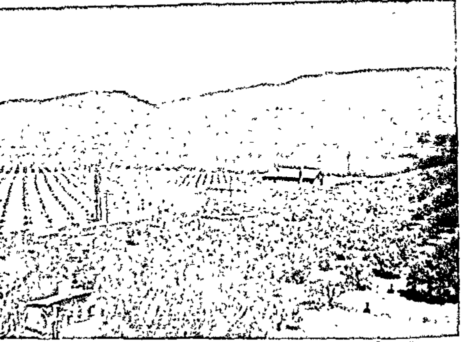
Accurate forecasting of weather demands great knowledge of all the weather factors. Weather conditions are observed near the surface of the earth, and high above. Reports of weather conditions are used to make the weather map. The weather map is the forecaster's most important tool.

When you try your hand at forecasting, be sure to make a record of the prediction and what actually occurs. Then try to explain any differences.

Changing weather and different climates make it necessary for man to make adaptations. Many industries are dependent upon climate. Homes and clothing must be adapted to the type of climate of a region. Man cannot change the climate, but science teaches him how to adapt his life to it.

KEY WORDS

adaptations	growing season	storm paths
climate	heat capacity	thirty-day outlook
conduction	isobar	weather
convection	land breeze	Weather Bureau
forecast	radar	weather code
forecast center	radiation	weather map
frosts	sea breeze	weather station

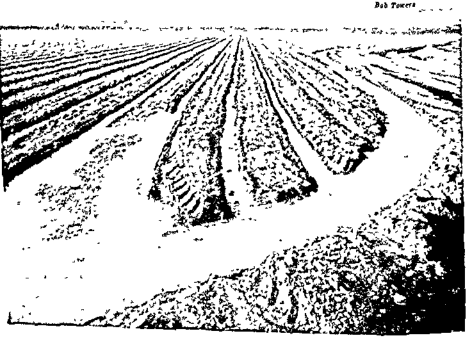


Frank Bolt

California Orange Grove—Note the smudge pots. Their dense warm smoke forms a blanket which protects the fruit against a killing frost.

Irrigation at Work—Modern scientific farmers often succeed where nature failed. Irrigation can make even a barren desert flourish.

Bob Towers



Key Statements

1. Scientific prediction of weather depends upon the collection of accurate weather information, and a knowledge of its cause-and-effect relations.

2. Weather predictions based upon weather signs are not likely to be accurate.

3. Weather forecasting involves a knowledge of the weather factors all over the country.

4. Weather forecasts sent out by the United States Weather Bureau are of great money value to industries of all kinds.

5. Substances differ in their capacity to absorb heat. Water has the greatest heat-absorbing capacity of any common substance.

6. Land has a smaller heat capacity than water. Land therefore warms faster and cools faster than water.

7. A land breeze (blowing from the land) occurs when the air pressure over the water is less than over the land.

8. A sea breeze occurs when the air pressure is less over the land than over water.

9. The difference in air pressure over land and water is due to the unequal heating of the air over each.

10. Because of the heat-storing capacity of water, regions near large bodies of water have a longer growing season than regions farther away.

Thought Questions

1. If water has eight times the heat-absorbing capacity of iron, how many pounds of iron would be required to contain as much heat, at a given temperature, as one pound of water?

2. Which would keep a person's feet warm longer, a hot brick or a hot water bottle with an equal weight of water at the same temperature?

3. Explain how the unequal heating of land and water results from their different heat capacities.

4. Why are official weather observations made at a given hour?

5. Why can one not make an accurate weather prediction using only a barometer?

6. How can a frost prediction be made? What factors must be known?

7. Why do weather stations use a code to send their reports to forecast centers?

8. Where is the weather forecast for your region made?

9 Is white cotton a sensible material for summer wear? Give reasons for your answer

10 Why are woolen gloves warmer than cotton gloves?

11 Name one industry near your home that is dependent upon weather or climate. Explain how.

12 Explain why it may be warm and uncomfortable at the seashore in the evening after a warm day. Is the land breeze or the sea breeze likely to be cooler and more refreshing after a warm day?

PROJECTS FOR YOUR SCIENCE DISCOVERY BOOK

1 List all the ways you can determine in which weather reports by radio are useful

2 Practice making weather predictions until you become proficient Keep careful records of the weather factors, your prediction, and the final outcome

3 Select a locality near one of the Great Lakes From Weather Bureau reports determine the latest average date of killing frost in the spring and earliest average date of killing frost in the fall, within two miles of the lake shore and 25 miles to 30 miles from the shore What is the average length of the growing season in each location? How is this related to land and sea breezes? Record all your findings

4 Make a list of the important crops of your vicinity and the industries related to them Explain the relationships

5 Discuss the ways in which unusual weather conditions, such as late frosts in spring and too much or too little rain, may determine the abundance or scarcity of food

6 List the principal occupations in your community and tell how each is related to the weather conditions and what adaptations are made to meet these conditions

7 List the weather hazards to health in your community. Tell how you can adapt yourself to these conditions so as to keep well

8 At night sink a shallow glass dish in the earth so that the top is level with the surface of the soil Fill it with water. It should be located where the sun will shine on it next morning.

Early in the morning place one thermometer in the dish of water and stick one in the soil near it

Note the temperatures of each, and after the sun has shone on them for two hours, again note the temperatures Explain your observations

9. Put two shallow dishes of water out overnight in a place where they will receive sunlight in the morning In the early morning place

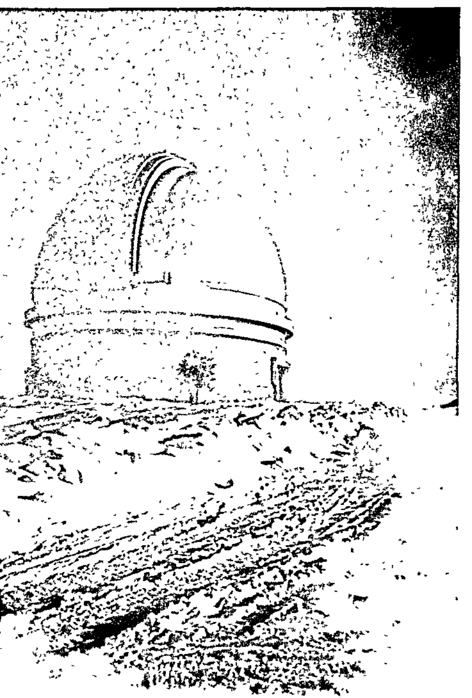
a thermometer in each and cover one with a white cloth and one with a black cloth. Note the temperatures at the beginning and the end of one hour of the sun's heating. Explain your discoveries.

10. Determine the relation between wind direction and air temperature.

11. Make a study of four different industries to determine their dependence on the weather.

12. Study the effect of weather and climate on six leading crops.

13. Find out how it happens that many fruits, flowers, and vegetables can be grown successfully north of the Arctic circle, in spite of the very short growing season of that region. *Hint:* Consider the influence of sunlight on plant growth; also, the varying lengths of day and night in the Arctic region.

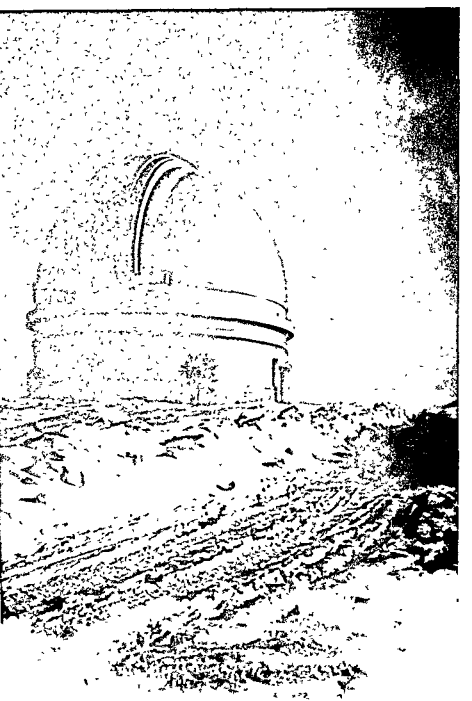


R. Morris

Palomar Mountain Observatory, California.—Here the great, 200-inch telescope, largest in the world, is used by astronomers to study the heavens. The domed top of the observatory revolves, so that the telescope may be trained on any part of the sky.

UNIT II

The Heavens



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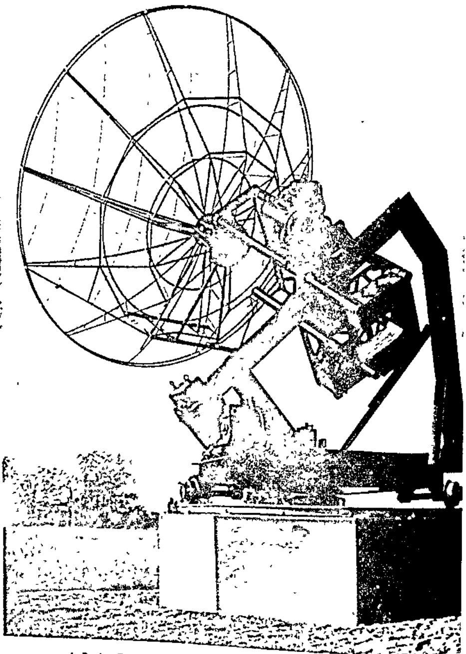


Science Service

A Radio Telescope—Ordinary telescopes use mirrors or lenses to focus light from distant objects. This telescope picks up radio waves from the sun. The apparatus follows the sun and records conditions on it which interfere with certain types of radio reception.

TOPIC V

The Roof of Our Environment

DO YOU KNOW—

1. Why stars shine?
2. What a constellation is?
3. What the Milky Way is?
4. What a light year is?
5. Whether the stars control your fortune?

GENERAL PROBLEM 1

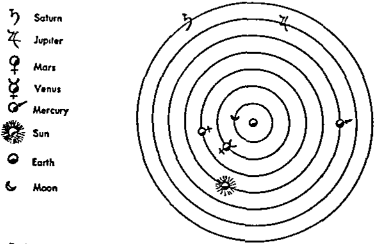
What Are Stars and Constellations?

STAR-LORE.—Do you think that the stars in the heavens are on the inside of a great hollow globe which turns about the earth? Or do you know that the earth turns, making the stars appear to move?

Long, long ago, before men became scientific, a man named Ptolemy told the people that the earth was the center of the universe. He said that all bodies in the universe revolved about the earth. To him the earth was the most important part of the solar system. It is to us, too.

But Ptolemy was wrong about what turned. It is the earth that turns. Even so, the ancient people learned much about the stars. They knew how to use them for finding directions and for telling time and the seasons. After a while they discovered that stars, planets, the sun, and the moon rise and set because the earth turns. They observed that the stars in the north appeared to move in circles around one particular star we call the North Star.

Some of the stars are so arranged as to form interesting shapes or figures, such as the Big Dipper. Not only do the stars that circle about the North Star form figures, but stars in other parts of the heavens form groups, too Ancient people gave



Ptolemy's System.—Study this diagram and see how Ptolemy thought that the planets and the sun all revolved around the earth. We know today that this is not true Try drawing a picture of your own to show the proper relation of the sun and the planets.

names to these groups and made up queer stories about them. You can see some of these star groups and learn the old stories about them.

For your study of the stars you will need a starry night, the star maps in this book or magazines, and your Field Research Notebook. The stars and star groups you learn to know will prove to be objects *of interest* as long as you live. They are not merely fair-weather friends. Even though the sky should be stormy, you will know just where they are, up above the storm. If you could ride in an airplane above the storm clouds, you would see them shining

FIELD RESEARCH

On a clear, moonless evening, you and a friend or two should star-gaze awhile. Go out into an open field, or on a hilltop, or out on a lake away from city lights. Just look, look, look. Here and there you will come to recognize a star, or a group of stars, by certain characteristics of brightness, position, or color which set it off from other stars in the heavens. It will help if you begin your star-gazing with the last fading twilight so as to see the first star that is bright enough to show. One by one other bright stars will appear. It is easier to learn to recognize the stars this way than when the sky is filled with "diamonds." Perhaps someone with you may know the name of a star group. Make notes of your first impressions of stars and drawings of star groups in your Field Research Notebook.

WHAT ARE THE STARS?—The stars are great *suns* like our sun, only some of them are much larger. For example, Betelgeuze (bĕt′el-gûz′) is over a million times larger than our sun. But it looks smaller because it is about 18,000,000 times farther away. These great hot bodies send out heat and light as does our sun. Because they are so far away, most of the heat is lost before it reaches us. But the light comes to us undimmed except by our own atmosphere. This light does not *seem* so bright and widespread as that from our own sun. It seems dimmer for the reason that the farther away you are from a glowing lamp, the smaller it appears and the fainter is its light.

The light from the faintest stars and the light from the brightest may be compared to the light from a firefly and the light from a powerful searchlight.

The twenty brightest stars or suns are called *stars of the first magnitude.* They are not the largest, but the *brightest* stars. It is these stars that are first seen as dusk deepens in the evening. They differ in *size, color* (blue, red, white), *composition,* and *position.* There are about 6000 stars that are bright enough to be visible to the naked eye although not from one position. Actually, only about 2000 stars are visible to the naked eye from one place of observation. It will be a good test of your eyesight to compare the number of stars you can see with what a companion can see. In ancient times ability to see certain stars was a test one had to pass to become a soldier. With appeared to move in circles around one particular star we call the North Star.

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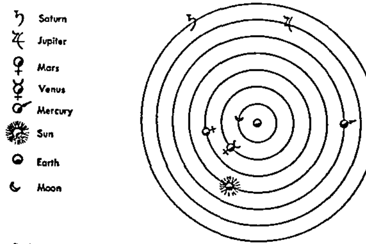

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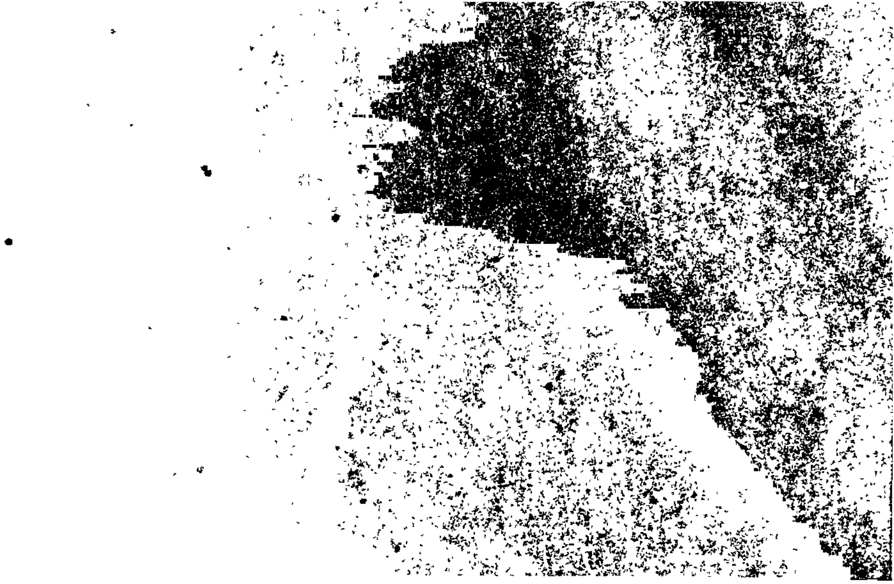
THE MILKY WAY.—Across the heavens, nearly dividing it into two parts, is a broad white path. It is one of the most striking things in the sky. It is called the *Milky Way.* Ancient Egyptians called it Pharaoh's River. They believed it was the river over which the spirits of dead Pharaohs sailed their boats. Before astronomers used high-power telescopes, the Milky Way was thought of as a mass of gas. It is now known to be made up of countless distant stars. The "milky" appearance is due to the fact that the stars of this group are so numerous and distant. Their "feeble" lights form only a lacy pattern. A good time to observe the Milky Way is during the fall and winter evenings when it is high in the sky. We shall learn later why it is now believed that the stars of the Milky Way are part of a great rotating system.

THE BIG DIPPER.—Can you see resemblances to kings and

Our Galaxy.—The Milky Way reaches entirely around our heavens. Our earth and the solar system are part of it. The densest part of the Milky Way is made up of the largest collection of heavenly bodies in our universe. Each white speck is a sun like ours. The large white spots are believed to be masses of suns.

Yerkes Observatory



The Big Dipper.—This constellation can always be seen from our country. Note the double star second from the end in the handle. These two stars can be observed in the sky without a telescope.

queens and to animals as did the ancients when they studied the star groups in the sky? One ancient race gave us the name "constellations" for these star groups. One you know is the *Big Dipper.* Because it is so close to the North Star it never passes below the horizon as do star groups farther away from the North Star. It is called "the Dipper" because its seven stars are arranged in the shape of a dipper. Four stars mark the corners of the bowl, and three form the handle. If your eyes are good and the night is clear, you may be able to see a faint star near the second star of the "hȧndle" of the Dipper. This star is shown in the picture above. With an opera glass you can see some other stars in the Dipper too faint to see with your naked eye.

The Big Dipper is a good place to start to learn other constellations. Cassiopeia (kăs′ĭ-ō-pē′yȧ) can be seen across the North Star from the Big Dipper. The Northern Cross and Peg′asus are higher in the sky. They can be seen in the summer and fall months. Orion (o-rī′on) can be seen during the winter months.

Orion the Hunter—Orion is quite near another constellation, Taurus the Bull. The ancients imagined that Orion was pursuing Taurus across the sky. Around the middle star of Orion's sword handle is a great nebula.

How Imagination Named the Constellations.—All of us have let our imaginations form fanciful pictures in the flames of the fireplace, or in the delicate tracery of frost on the windowpane, or in the changing cloud forms of a glorious sunset. In the same way, the people of long ago drew mind pictures on the sky heaven with star groups as outlines. The names of many of their mythological heroes were placed on pictures of the star groups. As time went on, stories, or *legends*, were made up about the stars and star groups. Of course, the legends are not true. But they are interesting, and they do tell us much about these early people.

You will want to read about some of the star legends. Different people had different stories about the same stars. A good project for your Science Discovery Book would be to write down some of the different stories about the constellations. Some of the books listed in the Bibliography will tell about these ancient myths.

LIBRARY RESEARCH

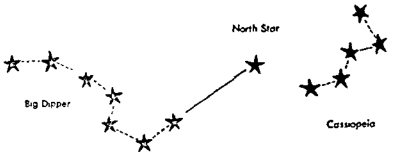
Whenever you learn of a new constellation, go to a good book on mythology or to some similar reference book to see if you can discover the reason for its name. This will not only reveal many an interesting story, but will also help you to become better acquainted with the star groups.

The seven stars of the Big Dipper always appear in exactly the same relative position or pattern. The positions of the stars of this constellation are fixed with respect to each other. But the constellation as a whole seems to swing around a point in the northern sky like the hand of a great clock, only in the opposite direction.

FIELD RESEARCH

Observe the position of the Big Dipper soon after dark in the evening, and again two or three hours later. Repeat the observations several nights later. In your Field Research Notebook record the time of night and dates when you make each observation and make a star map of that part of the heavens, showing especially the Big Dipper. Did you notice that the point in the sky about which it appears to turn is marked by a bright but lonesome star? Did you know that the Big Dipper is always above the horizon in the north temperate zone?

THE NORTH STAR.—You have probably guessed by now that the lone star about which the Big Dipper appears to turn is the *North Star* or *Polaris*. It is easy to find the North Star. Sight along the line of the two stars which form the outer edge of the bowl of the Big Dipper. (See the diagram on page 130.) These two stars are called *pointers*. At a distance from the top of the bowl of about five times the apparent distance between the two stars themselves, you will always find the North Star. It is a fairly bright, lone star of the second magnitude.



After you have studied this diagram, go out on a clear night and locate the Big Dipper. Follow the line shown and find the North Star and Cassiopeia. The distances of the North Star from the Big Dipper and Cassiopeia have been shortened in this diagram.

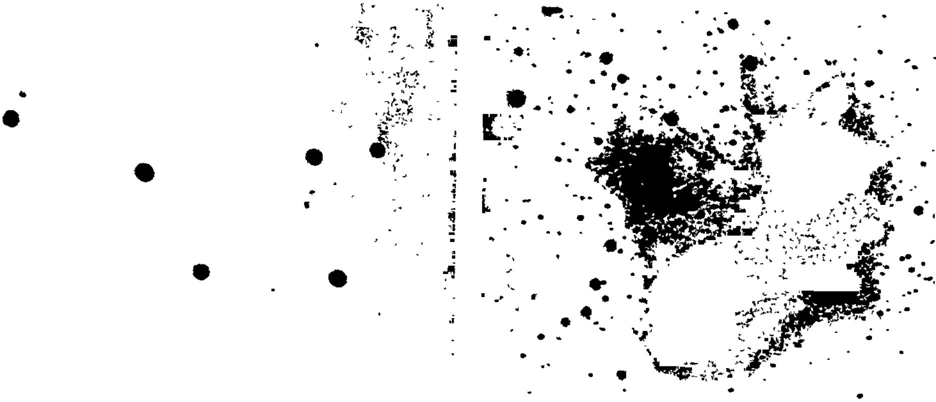
FIELD RESEARCH

If you can obtain an old umbrella, open it up and on the inside paste paper stars to represent the Big Dipper. Paste a star about the rod or handle where it goes through the umbrella. This will represent the North Star. Turn the umbrella counterclockwise and you can illustrate the apparent motions of the stars. Each complete turn will represent 24 hours. Can you also represent the Little Dipper and Cassiopeia?

FINDING OTHER CONSTELLATIONS.—On the opposite side of the North Star from the Big Dipper are five conspicuous stars forming a rather flattened W. These five stars are part of the constellation *Cassiopeia*.

On a clear summer evening look overhead to see six stars in the form of a cross, lying nearly along the Milky Way. The Latin name of this constellation is *Cygnus* (sĭg'nus), meaning "swan." Its popular name is *Northern Cross*. It lies in the heavens nearly at right angles to a line from the Big Dipper to the North Star. (See star maps, pages 136, 137.) The bright star at the head of the "Cross" is Deneb. The "Cross" is not always above the horizon, as is the Big Dipper. It is visible only during the evening hours of the summer and autumn months.

In the fall try to locate Andrŏm'eda, and Pegasus. These are also shown on the star maps.



Yerkes Observatory

The Seven Sisters.—(Left) Six stars in this constellation can be seen with the naked eye. Some people can make out a seventh star (upper left). (Right) Here are the nebulae surrounding the Pleiades, which is actually made up of many, many stars. Most of the stars of the Pleiades can be seen only with a telescope.

The Little Dipper can be seen every month of the year. The North Star (Polaris) is the end star of the handle of the Little Dipper.

The Pleiades (plē′a-dēs), sometimes called the Seven Sisters, is a part of the constellation Taurus—the Bull. Look for the Pleiades during the winter months. The seven stars form a very "little dipper."

One of the most beautiful winter constellations is Orion, the Hunter. Look for the three bright stars of the "belt" high in the southeastern sky or where shown on your star map. The bright reddish star to the left and above the belt is the great sun Betelgeuse. Do you remember how far away Betelgeuse is?

The constellations have no scientific importance except that they serve as a means of locating and naming various stars. For convenience, the astronomer calls the brightest star of each constellation *Alpha*. The Alpha star of the Big Dipper happens to be the one nearest the North Star. The second brightest star is called *Beta*. Often, the Greek letters α, β, and so on are used instead of the words. It must be remembered that the brightness of a star depends mostly upon its distance away from us. The Alpha star of one constellation may therefore be brighter than the Alpha star of some other constellation.

FIELD RESEARCH

In the fall months try to identify the following stars, which are the first to appear as darkness comes on: Vega of Lyra almost overhead, Deneb of the Cross, Arcturus of Boötes, Altair of the Eagle, Antares of the Scorpion, and of course the stars of the Big Dipper and other groups you have studied in the northern sky

If your observations are made during the winter months, look for Betelgeuse and Rigel in Orion, Aldebaran in Taurus.

Perhaps you have noticed that a particular star with which you are acquainted, Vega for example, is overhead about 9 o'clock in August In September at the same time you find Vega has moved from overhead toward the west The reason for this is that the stars rise about four minutes earlier each night Therefore, in a month a star will gain about two hours by your watch In twelve months a star will gain about 24 hours or one day So you see a star each August in the same position. However, in six months the star would be overhead about noon, and so you could not see it Knowing about the early rising of the stars will help you to understand why star maps have the names of the months around the circle.

STAR SUPERSTITIONS —The movements of stars are governed by the laws of nature. There are some people, however, who do not know this fact.

> Star light, star bright,
> First star I've seen tonight,
> I wish I may, I wish I might,
> Have the wish I wish tonight.

Of course you have said these magic words and wished many a time. But your study of science will convince you that the stars have nothing to do with the outcome of your wishes

There was a time when man thought that his fate was somehow fixed by the stars. The astrologers of old thought they could read the future in the stars This was merely superstition. Even today there are people who study the stars to learn the fate of nations and of men. You will find articles by astrologers in the newspapers Read them and test the statements scientifically to find if they are true or imaginary. Science has displaced such superstition by a true knowledge of the stars and of their actual relation to our sun and our world.

GENERAL PROBLEM 2

How Far Away Are the Stars?

MEASURING DISTANCE.—How many inches is it from New York to Chicago or San Francisco? You could calculate the distance in inches, but the number would be too large for convenience. The mile is a better *unit of measure* for distances between towns and cities. You would use inches in telling the size of this book, or feet to measure the length or width of your room. In other words, to speak of distances it is necessary to have a convenient *unit of length*. A few of the common units of length are the *inch*, the *foot*, the *yard*, and the *mile*.

The distances between the earth and the stars are very great. They are so great that we must have a special unit of length to measure them. It must be a very long "yardstick" so that we can represent the distance of a star in numbers easy to use.

Try to imagine a table 186,272 miles long. At the far end stands a boy with a powerful electric light. Suppose at a given signal the boy turns on the light. Just one second later the light will reach your eye. The light has traveled the full length of the table, 186,272 miles, in a single second.

Light actually travels at this tremendous speed of 186,272 *miles in one second*. To get an idea of this speed, recall that the earth is about 24,000 miles in circumference at the equator. Therefore, 186,272 miles is nearly eight times the distance around the earth. Light, then, travels in a straight line in one second a distance equal to nearly eight times the circumference of the earth. (For ordinary calculations the even number 186,000 is accurate enough.)

THE LIGHT YEAR.—When the astronomer measures the distance between the earth and a star, his unit of measure is the *light year*—about six trillion miles. One light year is the distance light travels in one year. *Alpha Centauri* is a star of the first magnitude, visible in southern latitudes. It is the nearest bright star that we know. Yet it is so far away that it takes four years and four months for its light to reach us. Another and fainter star in Centauri, called *Proximus Centauri* ("proximus" means "nearest"), is a little nearer. Light from it takes four years and two months to reach us. It is the nearest star. To write the distance of either star in miles would mean a long string of numbers. So astronomers use the astronomical unit, the light year, to measure these distances from us.

How can we understand the great distances of the stars? A train traveling at the rate of a mile a minute would take 47,000,000 years to make the journey to Alpha Centauri. To make this journey on a mile-a-minute train, you would need to live 670,000 times the ordinary length of life. And remember, Alpha Centauri is the second nearest star of all!

AN ARITHMETIC PROBLEM

Write down on your paper the number 186,000 and multiply this by 60. Your answer will be the distance that light travels in *one minute*. Multiply this number by 60 (60 minutes in an hour), then multiply by 24 (24 hours in a day), and then by 365 (the number of days in one year), and your answer will be the number of miles that light will travel in *one year*. This will be 5,865,696,000,000. You may have trouble in reading this number unless you recall the order—hundreds, thousands, millions, billions, trillions, quadrillions, etc. This number can be read but is too vast for us actually to sense. It is the distance in miles that light travels in one year in a straight line. This is called the *Light Year*. It is the "yardstick" of the heavens. In round numbers we may use six trillion miles.

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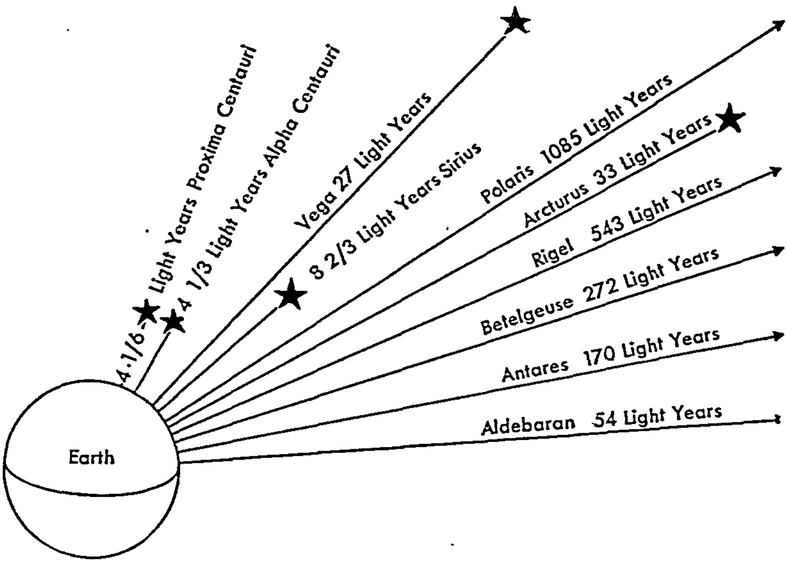
Star Distances.—The diagram on page 135 shows how far away some of the familar stars are. It will help to remember that a mile-a-minute train would take more than 10,000,000 years to travel *one* light year.

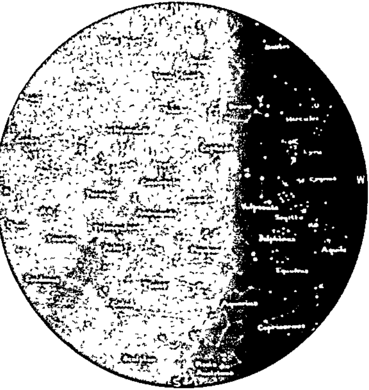
Though such distances are hard to understand, mathematics, photography, and the telescope make it possible to measure the distances of stars with great accuracy. They are measured by observing a star's position against a background of more distant stars. Six months later, the star's position is again observed against the background stars. During the six months, the earth has moved half way around its orbit. Thus the star is observed from two points 186,000,000 miles apart. The difference in observing from these two points causes the star



Star Distances.—Try to adjust your mind to the tremendous distance that is indicated by just one "light year." Do you understand how astronomers can study a subject so far from their reach?

to appear to change its position. The distance of the star is calculated from this apparent change of position. The more distant the star, the more difficult it is to measure its distance accurately. New measurements are constantly being made by astronomers. If you find that the distance given for a particular star differs in books of different dates, it may be because new measurements have been determined. Scientists are always trying to make measurements more accurate, and so you must expect new figures from time to time.

Red Hot Stars.—Stars are great suns. They are huge quantities of matter, extremely hot and probably gaseous. The temperatures of the stars vary from 41,000° F. for blue stars and



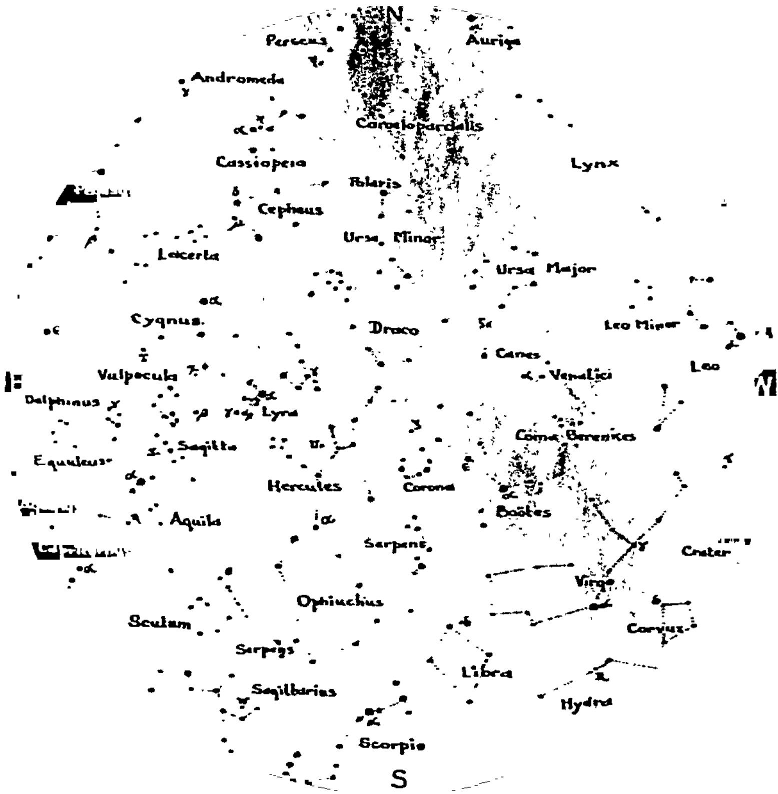
The American Museum of Natural History

Winter Sky Map—Face south and hold the map over your head so that the letter "N" is in the direction of due North. The map will then show the location of the stars in the heavens.

12,000° F for those like our sun, to 2800° F. for red stars. Here also new measurements are being made as instruments are improved.

Where one star was known by the ancients, now a million stars tell their stories to the scientist who knows how to study them. The color of the stars has helped the scientist determine their temperatures.

Stars Really Move.—The stars appear to maintain fixed patterns in the sky. Yet scientists know that stars change their relative positions at rates of 10 to 20 miles per second. Some move much faster. Arcturus is thought to be changing its position at the rate of about 75 miles per second. In 800 years



The American Museum of Natural History

Summer Sky Map.—The constellations near the North Star are visible in summer as well as in winter. Note the new constellations that appear in this map and not in the previous one.

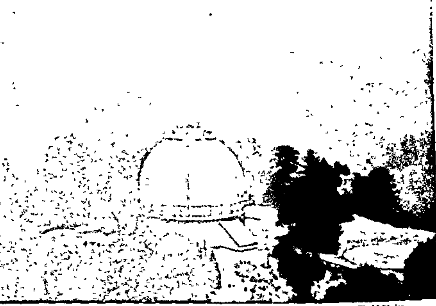
FIELD RESEARCH

To understand how a star seems to change its position against a background of stars, try the following:

Hold a finger at arm's length. Close one eye and sight at the background. Then close that eye and open the other, and again sight at the background. Do not move your finger. Note that your finger seems to "jump"!

Your finger is the "star" whose distance is to be measured. The distance between your eyes is the "diameter of the earth's orbit." The "jumping" of your finger corresponds to the star changing its position against a background of other stars.

This "jumping" or change is called *parallax*.



Mt Wilson Observatory, California.—Mountains are considered good places to build observatories. This is because the air is more transparent there than it is at sea level and there are fewer cloudy nights.

this will change its location only about the width of the moon. So in our lives it is practically true that the stars do not change their locations.

FIELD RESEARCH

Repeat the preceding Field Research, page 137. This time compare the amount of "jump" when your finger is held at arm's length, about 12 inches from your eye, and about 3 inches from your eye.

How does this help explain why it is more difficult to measure the distance of more distant stars?

METEORS, VISITORS FROM SPACE.—Have you sometimes looked up at the sky on a summer's evening and seen a "star" shoot across the heavens? Millions of these shooting stars, most of them no larger than a grain of sand, are moving about the sun and earth all the time. But we never see them until they enter the earth's atmosphere. By that time they can do no harm for they are heated so hot by the friction with our protecting atmosphere that most of them are burned up before they reach the earth.

Such "shooting stars" or meteors are not stars at all. They are bits of rock or dust. There seem to be clouds of such material scattered throughout our solar system.

Once in a while a shooting star (meteor) bigger than the others does reach earth. When a meteor actually reaches the earth, it is called a *meteorite.* Some of our museums have great pieces of meteoric rock which have been found in various places in our country. In Arizona there is a huge hole in the ground where a meteor fell thousands of years ago. The rocks on the sides of the hole are burnt. This tells us how hot the meteor must have been when it struck.

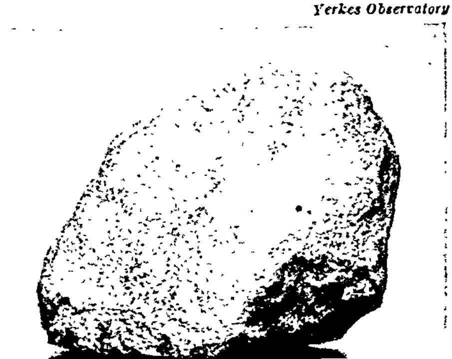
Records of ancient times and those of today tell of great displays of meteors. In November, 1833, it is recorded that the sky was full of "shooting stars." It must have looked like a Fourth of July celebration. Is it any wonder that primitive man feared such displays, when he could not understand them?

One star in this universe of ours is of more importance to us than all of the others put together. This star is the sun. Its relation to our world and to us will be our chief interest in our next topic—"Our Sun and Moon."

THINKING THINGS OVER.—Probably you have been interested in the stars for several years. You have often looked at the North Star, the Big Dipper, and other stars. By now you should be able to find your way among the stars as each

Solar Visitors.—This solar rock (left), a stone meteorite which weighs 745 pounds, was found in Arkansas. Such a large meteorite is very unusual. A tremendous meteor crater (right) in Arizona is 600 feet deep and nearly three quarters of a mile across. The meteor that caused it is believed to have struck at least 30,000 years ago.

Yerkes Observatory



Science Service

Sky Photography.—This especially designed meteor camera (left) will photograph forty times as many meteors at once as older sky cameras The new 5000-pound camera can even photograph meteors as small as buckshot The "shooting star" (right) is shooting across the lower part of the constellation Orion. (This picture was not taken with the new meteor camera)

season comes along. Can you show your friends the "forget-me-nots of the angels" and call them by name?

But, more than all this, has your study of the stars helped you to realize that our earth is just one tiny part of the great universe? Has the study helped you to appreciate great distances? Has your study of the vast roof of our environment helped you to realize that stars really differ in temperature, size, and distance?

Does the saying, "Hitch your wagon to a star," mean more to you now than before? A poet once described the sky as "powder'd with stars." Do you think that is a good description? If your answer is yes to some of these questions, you will be able to appreciate better than ever before the majesty of our solar system.

Key Words

Arcturus	light year	Polaris
Betelgeuse	magnitude	shooting star
Big Dipper	meteor	Sirius
Cassiopeia	meteorite	star
constellation	Milky Way	suns
Deneb	North Star	Vega
	pointers	

Key Statements

1. Stars are great suns.
2. Stars always appear in the same relative positions or patterns.
3. Certain groups of stars are called "constellations."
4. The stars are very far away from us, the distances varying for different stars.
5. The special unit of length used by astronomers is the "light year," the distance light travels in one year.
6. The stars have nothing to do with one's fate.
7. Superstition about the stars and how they control the life of man is being overcome by scientific truths about the stars.
8. The twenty brightest stars are called "stars of the first magnitude."

Thought Questions

1. How are stars like our sun?
2. By what means do astronomers measure the distances and count the number of the stars?
3. What facts prove that the stars do not have any effect upon your fate?
4. Why can you ordinarily see the stars only after it has become quite dark?
5. How can you locate the North Star?
6. Why do astronomers use the light year instead of miles when telling the distance of stars?
7. Would you give the distance from New York to San Francisco in inches or miles? Why?
8. How have astronomers by their constant study of the heavens added to our knowledge?
9. Of what value are the vivid and colorful old myths about the constellations?

Projects for Your Science Discovery Book

1 Locate and name at least three stars and three constellations new to you.

2 Draw a map of the brighter stars near the North Star. Indicate the constellations that are visible to you in this region. Allow space to enlarge the area covered by the map. You will be called upon to add to the map from time to time. This will be your own *star map*.

3. On the next clear evening, locate and observe the Milky Way. Write a brief description of it Why has it been called the Milky Way? Where is it found in the sky? Include in your report the value of telescopes in helping you understand what the Milky Way is.

4 If possible, visit a museum to study meteorites. Make a report on the composition of meteorites. If you have visited the Meteor Crater in Arizona, write a report describing the size and shape of the Crater. If there are no meteorites available for your study, read about some of the larger ones which have been found on the earth. Use your encyclopedia or other books in your library for reference

5. Ask your librarian for help in locating *National Geographic* magazines and other periodicals that tell about meteor craters which have been discovered recently. Compare these craters with the Meteor Crater in Arizona

6. Look up the biography of one of the great astronomers. Some famous astronomers are Johann Kepler, Pierre Simon LaPlace, Copernicus, Galileo, Percival Lowell Find out when the astronomer lived, where he lived, and his most famous discovery.

7 On the next clear evening, locate the constellation Cassiopeia. Observe the position of Cassiopeia in relation to the Big Dipper and the North Star Record Cassiopeia on your star map

8. Go to the library and look up some stories about Cassiopeia. Prepare an account of one story for your class. Include a brief report of the story in your Science Discovery Book.

9. Study the star maps on pages 136 and 137 to locate the position of Cygnus. (Cygnus, you remember, means "The Swan.") By what other name is this constellation known? On a clear night, search for Cygnus. Then make a map of Cygnus and its near-by stars.

10. Vega is one of the brightest stars in the summer sky. If possible, locate Vega by sky observation and indicate its location on your star map. Vega is the brightest star in the constellation Lyra (The Harp) shown in the maps on pages 136 and 137.

11. Locate the bright star Arcturus. It is the brightest star in the constellation Boötes (The Herdsman) shown in the star map on page 137. After you have observed Arcturus in the sky, show its position on your star map.

12. Locate Pegasus and Andromeda by sky observation. Find as much information as you can about these constellations. Then write your own story in your Science Discovery Book. Use the star maps in this topic to help find these constellations in the sky.

13. Try to identify the Pleiades with the naked eye. The Pleiades is a loose cluster of faint stars in the constellation Taurus (The Bull). See the star map on page 136 to help you locate Taurus. If there is someone with you when you observe the Pleiades, find out which of you can see the greater number of stars in the Pleiades. The number of stars you can see is a test of your eyesight.

14. On any clear night, study the stars of the Big Dipper with field glasses. Record how many "new" stars you can see with the glasses. Locate these stars on a drawing of the Big Dipper.

15. Prepare a report of the Hale telescope. Tell where it is, how it received its name, and what it is used for. Or perhaps you will want to report on the history and manufacture of the Hale telescope. How large is the lens? What problems were there in the manufacture of the lens? How was it transported? How long did it take to build the telescope?

16. Record in your Science Discovery Book a comparison of the Hale and Schmidt telescopes. How do they compare in size? What is each used for?

TOPIC VI

Our Sun and Moon

DO YOU KNOW—

1. How big the sun is?
2. What gravity is?
3. That all life depends upon the sun?
4. What causes an eclipse of the sun? Of the moon?
5. How far away the sun is?

GENERAL PROBLEM 1

What Is the Sun?

THE CENTER OF OUR SKY SYSTEM.—Have you ever wondered how big the sun is, how far away it is, and what its purpose is? Is it only to give us light and heat and to serve as a timepiece? Or does it serve us in still other ways?

Our solar system consists of nine known major planets (and their moons) and over one thousand smaller celestial bodies. All these revolve in fixed courses around the sun. These planets are at varying distances from the sun. They differ from each other in size, color, and the number of their moons. We shall study several of them in some detail a little later. Right now we are concerned with their "guiding star," the sun.

SUN FACTS.—The sun is a great mass of matter, heated white-hot. The temperature at the center is possibly as high as 40,000,000° F. It is wrapped in dense clouds of hot gases. These surface gases have a temperature of about 10,000° F. The sun is about 870,000 miles in diameter, or nearly 110 times the diameter of our earth. In volume, the sun is 1,300,000 times as large as the earth. In other words, 1,300,000 earths could be "poured" into the sun.

GRAVITY ON THE SUN.—You are held to the earth's surface by the *force of gravity*. This same force causes an apple to fall from a tree. It causes the water in the rivers to flow to the sea. This force of gravity is the force which a heavenly body exerts on objects on or near it. We do not know what gravity is. We only know what it does and how it behaves. The effect of this unknown force extends to the farthest star.

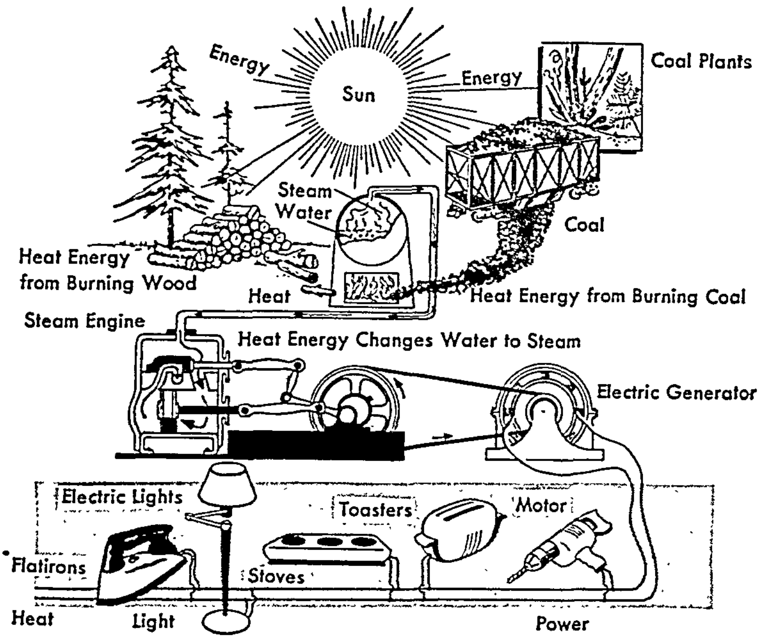
The force of gravity of the earth tends to draw all objects on or near its surface towards the center of the earth. Because of this "drag," you must have strong muscles to jump over a bar three or four feet high. Because of the great mass of the sun, the force of gravity at its surface is 28 times as great as the force of gravity of the earth. If you were on the surface of the sun, you would have hard work to jump over this textbook. (Can you give two reasons why no one could live on the sun?)

There is another interesting comparison of the force of gravity of the earth and of the sun. A man weighing 150 pounds on the earth would weigh nearly 4200 pounds, or more than two tons, on the sun. These numbers are given to help you appreciate what an enormous object the sun is—1,300,000 times as large as the earth.

WHAT IS THE DISTANCE TO THE SUN?—This great white-hot body is vast in size as compared with the earth. It is still more vast as compared with our moon. Yet it looks no larger than the moon itself. This is because the sun is so far away. Our mile-a-minute train running day and night could reach the moon in about six months if such a trip were possible. It would require about 177 years to reach the sun.

Such distances are tremendous, and yet we must try to realize what they mean. The average distance of the sun from the earth is about 93,000,000 miles. Traveling at the speed of light, about 186,000 miles a second, one could make the journey from the earth to the sun in about eight minutes. Compared with the distances of other suns or stars about which we have studied, the sun is very close to us. And because it is comparatively close, it affects our lives in many ways.

THE SUN AS A POWERHOUSE.—We think of energy to run our machines, heat our homes, and cook our food as coming from burning coal, oil, or gas. We are interested in the great power projects in Tennessee, Hoover Dam, and others. But do you think of the sun as the greatest powerhouse of all? Study the diagram below.

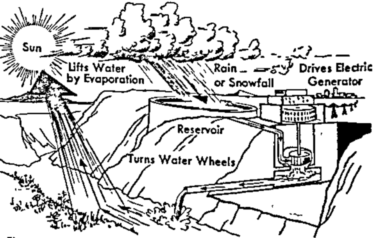


Our Chief Source of Energy.—Use this diagram to tell the story of how we get our artificial light, heat, and power from the sun.

Can you think of any other kinds of power we receive indirectly from the sun? The sun sends forth energy which plants use to grow and manufacture food for animals. Green leaves store the sun's energy as food energy for the use of the animals. Every square yard of the earth's surface receives energy from the sun at the rate of $1\frac{1}{2}$ horsepower continuously.

Nevertheless the whole earth receives less than one billionth part of all the energy given out by the sun. Some of the energy of the sun, stored up through the ages in coal-forming plants, is now tied up in our coal. As we burn the coal this solar energy is given off as heat to keep us warm and to supply us power.

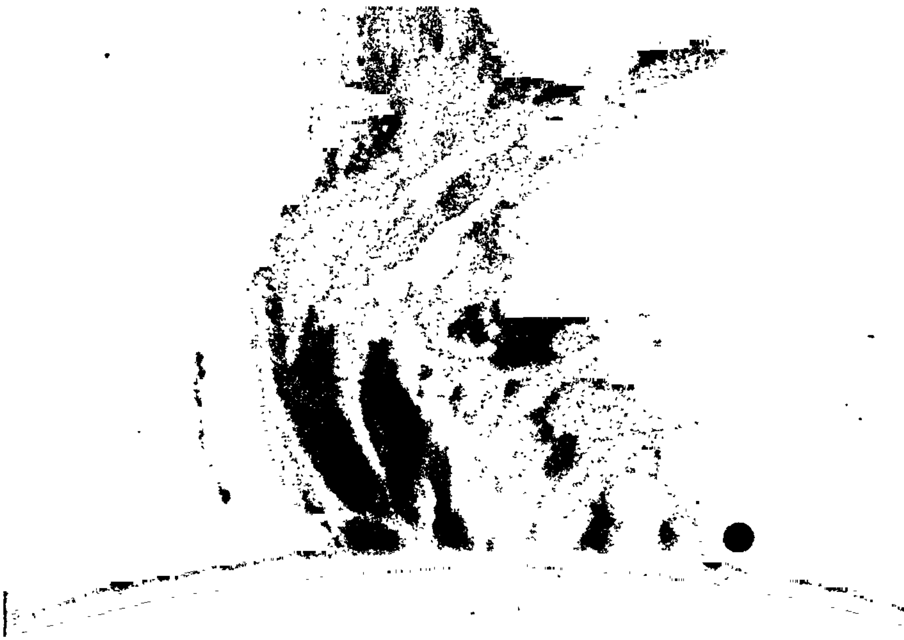
Heat from the sun causes the evaporation of water from land and sea into the atmosphere. *Evaporation* is the process by which water changes from the liquid to the gaseous state. It rises into the atmosphere as an invisible gas. When the gas cools, the water again becomes liquid by *condensation*. It forms clouds from which the moisture falls as rain or snow. This water cycle carries water from oceans, lakes, and rivers to mountain slopes and hillsides. As it flows downward, it may be used to drive water wheels and turbines, as is shown in the drawing. Hence water power really comes from the sun.



Electricity from the Sun—in a "round-about" Way.—Explain how it is that the sun really drives the electric generator.

Also certain rays of the sun's energy give us light. This is our sunlight which makes possible so many of our daytime occupations. The sun is the source of energy on which our activities and our very lives depend. A great astronomer said, "We are children of the sun."

Scientists are trying to discover the cause of the energy of the sun. Is the sun gradually cooling off as a hot iron cools? Or are forces at work in the sun itself that serve to produce more energy? The answer seems to be that the sun is producing



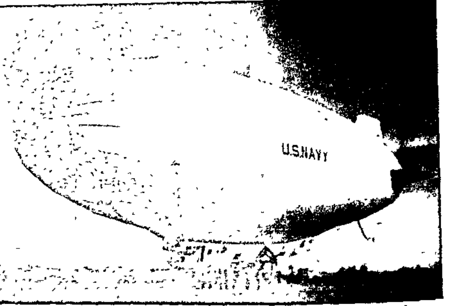
Courtesy Mt. Wilson Observatory

The Sun and the Earth.—This photograph was taken from Mt. Wilson Observatory. The curve across the bottom of the picture is the surface of the sun. Compare its size with that of the earth, represented by the white disc. The flames are really hot gases, 140,000 miles high!

more energy all the time. Most scientists now believe that the sun's energy comes from a splitting and rearrangement of atoms. It is a kind of atomic energy on a gigantic scale. Although carbon, nitrogen, and hydrogen are involved, scientists are not yet sure just how the process takes place.

Sun Substances.—Man has not always known what elements make up the sun. Little more than a lifetime ago the composition of the sun was not known. Now, by means of the *spectroscope* and other measuring instruments, much is known, especially of the outer gaseous portion of the sun.

When certain substances are heated very hot and looked at through a spectroscope, combinations of colored and dark lines are seen. The same combinations of colored and dark lines are given off only by the same substances. By applying this principle, it has been found that the sun has the same elements



Official U. S. Navy Photograph

U.S. Navy Airship —Patient scientific work has made dirigible service safer for the crews. Once hydrogen gas, highly explosive and inflammable, was used to fill dirigibles. Now, however, the non-inflammable helium is available for this purpose, and many disasters are avoided.

as the earth and the other planets. This is a fact which makes it seem reasonable that the sun and its planets were once a single mass of matter

FIELD RESEARCH

With the help of a physics or chemistry teacher, arrange to observe the bright, colored lines in a spectroscope

Elements may be metals, such as iron, zinc, and tin. Elements may also be non-metals, such as oxygen, carbon, nitrogen, hydrogen, and the like. The metals magnesium, iron, silicon, and sodium are very common in the sun's outer portion. Of course they are in the form of gases, heated very hot. These same elements, in the form of solids, are found in the rocks that make up the earth.

Scientists are not too certain about the proportion of the different elements in the sun's atmosphere. It is estimated that hydrogen makes up 90% to 95% of the total volume. Oxygen and helium may form only 2% to 4%. The rest is probably made up mostly by magnesium, iron, silicon, and sodium.

Helium has an interesting story. It was first discovered in the sun's atmosphere. Some time later an English chemist discovered that it existed also in the earth's atmosphere in very small quantities.

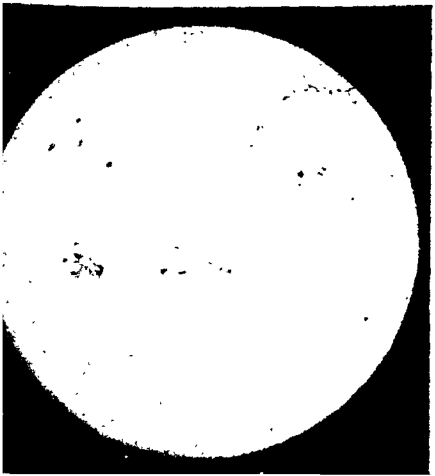
About 35 years ago helium was discovered in some kinds of natural gas. Scientists found out how to separate it from the gas. But it was very expensive. Scientists kept at the problem until great quantities could be obtained cheaply. The gas helium is so very light it is used to fill dirigibles. It will not burn. Therefore it is much safer to use for this purpose than hydrogen.

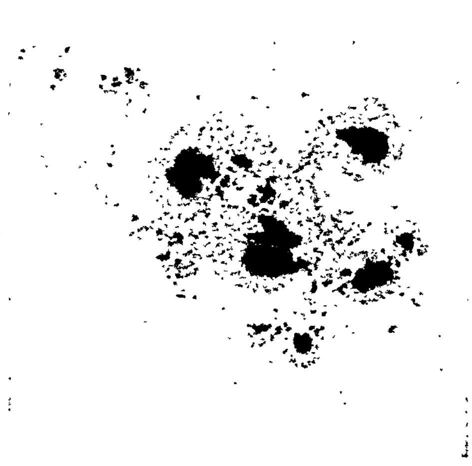
Sun Spots.—The outer portion of the sun is the sun's atmosphere. It consists of very hot gases. These gases are made up of molecules which move about constantly. When gases are heated very hot, the molecules move very fast. Toward the interior of the sun, where it is still hotter, the violence of the motion probably increases.

In some unknown way, the violent motion of the molecules produces great whirls of gases on the sun's surface. These whirls seem to be terrific storms. In comparison, our tornadoes

Sun Spots.—*These pictures were taken during the same period of sun spot activity. The picture on the right is a close-up. Each sun spot is about half again as large as our earth.*

Courtesy Mt. Wilson Observatory





are a mere trifle. These whirling gases form dark spots in the sun's atmosphere. They look like dark holes in the sun's white surface. These dark spots are called sun spots. They are a few thousand degrees cooler than the sun's surface. Sun spots vary from 500 miles to 50 000 miles in diameter.

Just as thunderstorms in our atmosphere occur more frequently at certain seasons and in certain zones, so it seems that sun spots occur more abundantly in certain zones of the sun. Also, the sun spots increase and decrease in number quite regularly, approximately every eleven years. A minimum of sun spot activity occurred in 1933. About 11 years later, 1943–1944, sun spots were again at a minimum. There was a maximum of sun spots in 1937–1938, and again in 1948–1949. If sun spots continue to behave with the same regularity as they have in the past, it is expected by astronomers that there will be many sun spots again about 1960.

The Aurora Borealis over New York.—Here is how the dazzling northern lights look from Manhattan. In the foreground is part of New York City. Behind that is the Hudson River, and on the other side is New Jersey. Can you find the George Washington Bridge?

Wide World Photos

During sun spot activity it is believed that electrons are hurled like bullets toward the earth's atmosphere. This may help to explain the northern lights (Aurora Borealis) which are more frequent and brilliant at times of great sun spot activity.

Radio transmission and reception appear to be related to the height of the layer of air called the Kennelly-Heaviside layer. The position of this layer is known to be related to sun spot activity. This helps us to understand why local radio reception is better at times of sun spot activity and why long-distance radio is helped by fewer sun spots. Even one large sun spot, however, seems to have the power to interrupt, or "black out," most of our international radio communication throughout the world.

There is still much to be learned about sun spot activity. Some scientists now believe that the positions of the planets may influence sun spots. It is also believed by some that the size of the sun spot is not as important as once thought. The age, activity, type, and position of the spot seems to be much more important.

Many observers have tried to discover relationships between sun spot activity and the weather. There is some evidence that weather is related to sun spots. However, much more research is needed before we shall know how the spots affect the weather.

GENERAL PROBLEM 2

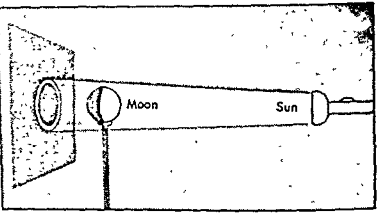
What Causes Eclipses?

FIRST STOP: THE MOON.—"First stop, the moon." This would be the announcement by the stewardess of an imaginary sky ship if we were starting on a visit to members of the solar system. Of all the objects in the heavens, the most familiar one is the moon. It is the body most looked for, and the one about which the greatest number of stories have been written. When visible, the moon is the most conspicuous object in the evening sky. It always attracts our attention.

The moon is strictly our property. It belongs to our earth and revolves around it once in about twenty-nine days. It is a solid ball about 2160 miles in diameter and is nearly 240,000

EXPERIMENT 13

How does the moon give light?



In this experiment we meet another form of energy. We have used heat and electrical energy Now we use light energy Light energy really results from heat energy.

The important idea in this experiment is to illustrate what many of you already know—that we can see things only because they are lighted up (that is, illuminated) But do you know if that is how we see the moon? Does the moon make its own light or does some other object light it up?

WHAT TO USE —A golf ball to represent the moon; support for the ball, a flashlight to represent the sun; a piece of black cloth; and a room that can be darkened

WHAT TO DO.—Make the room so dark that you cannot see the ball when it is held across the room with the cloth behind it Of course you can do the experiment at night by turning out the lights. Then let a pupil behind the class turn the beam of light from the flashlight on the ball.

WHAT HAPPENS.—Does the ball become light enough to be seen when the beam of light strikes it? What does the ball do to the light?

Does the cloth appear as visible as the ball? Explain.

CONCLUSION.—Explain how you were able to see the ball. Where did the light come from?

Why did the ball show light while the cloth did not do so?

APPLICATION.—Explain how light from automobile headlights makes objects alongside the road visible. How do automobile headlights make cats' eyes appear? Why?

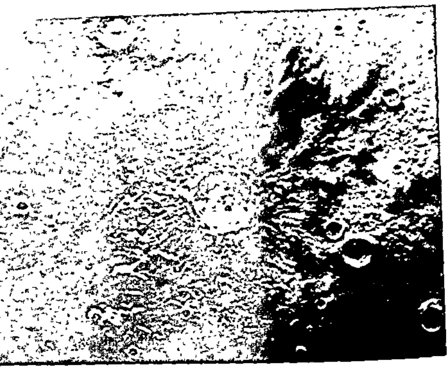
miles from the earth. Although the moon seems to be the largest object in the night sky, it is, nevertheless, very small when compared with the sun or the planets.

THE LIGHT OF THE MOON.—On a clear night the moon glows with much brilliance. Yet the moon really gives out no light of its own. The moonlight that you see is sunlight reflected from the surface of the moon. Most objects we see are made visible because light from some source falls upon them and is reflected to our eyes. A black object is black because it does not reflect light that reaches it. If it is really black you only see lighter objects or backgrounds around it. Black cloth does not reflect much light. A white ball would be invisible against it unless the ball were lighted up by light falling on it and being reflected from it. If the ball were really black, you would not be able to see it even if light were thrown on it.

If you try Experiment 13 you will be able to prove these statements. Even though you pretty well know in advance how some experiments turn out, it is worth while doing them. Almost always the experiment will help to clear up doubts or partly understood principles.

HIGH JUMPING ON THE MOON.—How high can you jump? When you jump up from the earth's surface, you jump against the force of gravity. Most people can jump upward in this way only a few feet. On the moon, however, you could jump over a train. This is because the force of gravity exerted by the moon is only about one sixth that of the earth. Therefore, a person could jump six times higher on the moon than on the earth. The 150 pound earth-man who would weigh 4200 pounds on the sun would weigh only 25 pounds on the moon.

Solids, water, and the gases of the air of the earth are held to our earth by the force of gravity of the earth. The moon, on the other hand, is so small that its force of gravity is not great enough to hold water vapor or other gases on its surface. That is why today it is a barren waste of rock—airless and waterless. The history of the moon is written in its craters, its long, barren valleys and high rugged mountain peaks. They have remained because there has been no leveling action of rain and snow, rivers, glaciers, and wind.



Moon Craters —The rough areas in the picture are mountain ranges, the smooth areas are plains. Why are the edges of the craters so sharp and clean cut?

Day and Night on the Moon —Another curious thing about the moon is that it turns on its axis only once in about twenty-nine days. Hence a whole day on the moon is nearly as long as our month. At any one place on the moon there would be continuous daylight for a little more than fourteen days. Then utter darkness for another two weeks of our time. Now it so happens that the moon's time of rotation on its axis is nearly equal to its time of revolution around the earth. Thus we see only one side or portion of the moon. This explains why we always see the same "man in the moon" No one on earth has ever seen the other side of the moon. Actually, 59 per cent of the moon's surface has been observed at one time or another. Forty-one per cent has never been seen.

Temperatures.—Daylight on the moon lasts a little more than fourteen of our days. The night is the same length.

During this long day of two weeks of our time, the rays from the sun, undiminished by any atmosphere, beat upon the surface of the moon. As a result of this long-continued heating, it is probable that the temperature of the rocks is raised as high as 244° F. But when the moon turns on its axis so that this same surface is away from the sun, its temperature drops rapidly to about − 250° F. During an eclipse of the moon its temperature fell 335° F.

In like manner, if our earth had no atmosphere, we should be baked by day and frozen by night. Fortunately for us, we have an atmosphere. The atmosphere and clouds about the earth act as a blanket which prevents rapid heating by day and rapid loss of heat by night.

We have learned that a warm body or object always tends to lose heat by *radiation* to colder objects or gases. For example, when you stand near a fire, the part of you toward the fire receives energy radiated (sent out in all directions) from the fire. The rest of your body does not receive any of this radiated energy. When the radiant energy strikes your body, it is changed to heat energy. It is radiant energy that is given off by the sun. It is changed to heat when it strikes our earth and moon and helps to keep them warm.

Seeing on the Moon.—Our atmosphere, with its moisture and dust, *diffuses* (scatters) light from the sun. This is what happens when sunlight passes through air with smoke or other dust in it. It is what you see when the light from the head lamps of a car shines through fog. The tiny particles of water diffuse or scatter the light. Since the moon has no atmosphere, the sun illuminates only those objects in its direct or reflected light. Where the light does not strike, there is darkness.

For example, suppose you had a house on the moon, a house with non-reflecting inside walls. In the rooms facing the sun, only those portions in direct line with the windows would receive light. The other portions would be darker than any nights we know. The rooms on the opposite side of the house would receive only that light which might be reflected from surfaces in the paths of the sun's rays.

The moon's surface is not so good a reflector of light as that of our earth. It is about equal to that of ordinary sandstone.

Shadows on the moon are very sharp. This is due to the absence of *diffused light* When there is an atmosphere such as our earth possesses, light is diffused. Thus an object held in a bright light on the earth does not cast nearly so sharp a shadow as that cast by any of the mountain peaks on the moon.

The moisture and dust particles in our air also give us our blue sky and colored sunrises and sunsets. On the moon the sky is black and there are no beautiful sunsets or sunrises.

FIELD RESEARCH

Hold an object between a bright light and the wall. Do you observe two depths of shadows—one darker than the other? How could there be any light behind the object, if it did not come in from the sides as diffused rays?

SILENCE AND THE MAN IN THE MOON.—When a person on the earth speaks, his voice is carried in all directions by wave-like motions of the air. The waves are somewhat similar to the waves spread from a stone thrown into water. On the moon there must be absolute silence, for there is no air to carry sound.

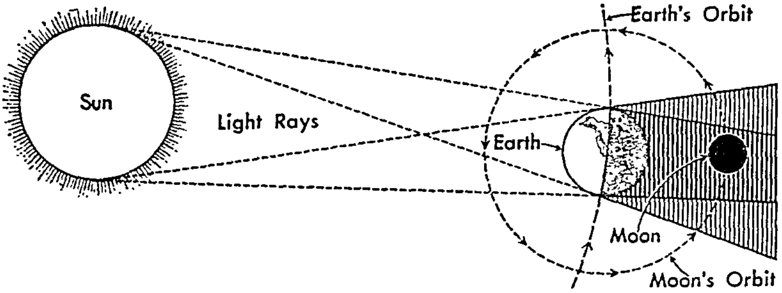
FIELD RESEARCH

If there is a physics teacher in your school, ask him to help your class prove that air carries sound. He will need a bell jar, exhaust air pump, and an alarm clock. If the clock is placed in the bell jar containing air and the alarm sounds, it can be heard If the air in the bell jar is taken out by means of the air pump and the alarm rings, the sound can be heard faintly or not at all, depending on how much of the air has been removed

We are conscious of air because it fans our faces, blows dust into our eyes, carries clouds along with it. It carries sound to our ears. It sometimes tears down buildings and trees. Yet to realize fully all that air means to us, we must bear in mind other work of air. Without air there would be no sound, places would be either very bright or very dark, and the temperature would be very hot or very cold.

AN ECLIPSE OF THE MOON.—The moon is visible by the reflected light of the sun. You can understand, therefore, that if an object passes between the sun and the moon, some of the light of the sun will be cut off. The moon will then be only partly visible.

This is just what happens during an eclipse of the moon. The earth itself gets in between the sun and the moon. When the sun, earth, and moon get into a straight line the shadow of the earth falls upon the moon. This is a *total eclipse* of the moon. Study the diagram on this page so that you may understand the positions of the earth and moon during a total eclipse of the moon.



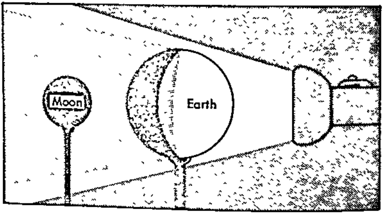
Eclipse of the Moon.—Compare this diagram with the one explaining the eclipse of the sun (page 162). Can there be an eclipse of the moon at any phase of the moon? Explain.

The shadow of the earth frequently covers only a portion of the moon's face. Then we have what is known as a *partial eclipse*. The edge of the earth's shadow on the moon's face is always circular. This must prove that the earth is shaped like a ball, for only a ball can make a circular shadow if it is turning on an axis all of the time.

Experiment 14 tells you how to set up a model eclipse of the moon. Of course you must keep in mind that the objects you use are only models. They do not accurately represent the sizes or distances of the sun, moon, and earth, nor will the motions be exact.

EXPERIMENT 14

What causes an eclipse of the moon?



Actually the diameter of the earth is about four times that of the moon, and the sun's diameter is about one hundred ten times that of the earth's diameter Before trying this experiment, you might draw lines on the blackboard to represent these diameters. Let one-half inch equal the moon's diameter, two inches the earth's diameter, and two hundred twenty inches (how many feet?) the sun's diameter.

This experiment will require patience—several trials to show clearly the eclipse of the moon

WHAT TO USE—A golf ball (moon); an indoor baseball (earth); and a flashlight (sun).

(The flashlight is not a true illustration of the sun, for the sun should be many, many times larger than the earth. Also if an indoor baseball represents the earth, the golf ball is much too large to represent the moon proportionally. With these differences in mind, however, these objects will serve for the experiment.)

WHAT TO DO—1 Make the room as dark as possible From behind the class let a pupil turn the light on the golf ball held in front of the class and rather high Let another pupil slowly carry the "earth" between the "sun" and the "moon"

If the room cannot be made quite dark, it may be necessary to set up the golf ball, baseball, and flashlight as in the drawing on a table.

2 Find a location for the earth so that the shadow of the earth just covers the moon. This will represent a total eclipse

3. Now start over again and move the earth so as to cause its shadow to appear first at the right of the moon Make the shadow cross the face of the moon from right to left, passing off the moon on the other side. The total eclipse occurs when the whole moon is covered.

4. Try to find a path for the earth so that only a portion of the moon will be covered as the earth is moved. Watch the shadow cross the moon without at any time covering the whole moon. This represents a partial eclipse.

5. Again place the earth so that its shadow covers a part of the moon. Turn the earth on an axis and note the shape of the shadow as the earth turns. Is it always circular?

WHAT HAPPENS.—1. Could you see the shadow of the earth on the moon?

2. Could you cause the whole moon to be covered by the shadow of the earth?

3. When the shadow moved across the moon was there a short time when the whole moon was covered?

4. What did you do to cause the partial eclipse?

5. Was the shadow circular? Did it continue circular in shape as the earth turned on its axis?

CONCLUSION.—What causes an eclipse of the moon? Why is the eclipse total sometimes and partial at others? How does an eclipse of the moon help to prove that the earth is round?

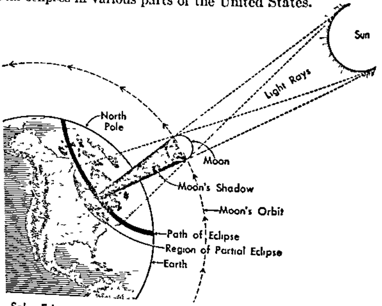
APPLICATION.—Explain how the moon might eclipse a star or planet.

Lunar Eclipse.—These pictures were taken every seven and a half minutes during an eclipse of the moon. The eclipse begins at lower right as the earth swings between the moon and sun. At upper left the earth has shut off most of the sunlight from the moon.

Wide World Photos

AN ECLIPSE OF THE SUN.—Sometimes the moon gets between the earth and the sun and cuts from our view a portion of the sun's face This causes an *eclipse of the sun.*

The most recent total eclipse of the sun visible in the United States (Idaho and Montana) occurred on July 9, 1945. Not again until July 20, 1963,[1] will another total eclipse of the sun be visible in any part of the United States. The eclipse of 1963 will be visible in its totality in Vermont, New Hampshire, and Maine. In 1970, on March 7, a total eclipse will be visible in Florida Others will occur in 1979, 2017, 2022, 2045, visible as total eclipses in various parts of the United States.



Solar Eclipse.—When the moon moves into position so that it blocks sunlight coming to the earth, there is a solar eclipse. In this diagram, the dark band across Canada and the United States represents the region where there is a total eclipse. How would the sun look to an observer in that region?

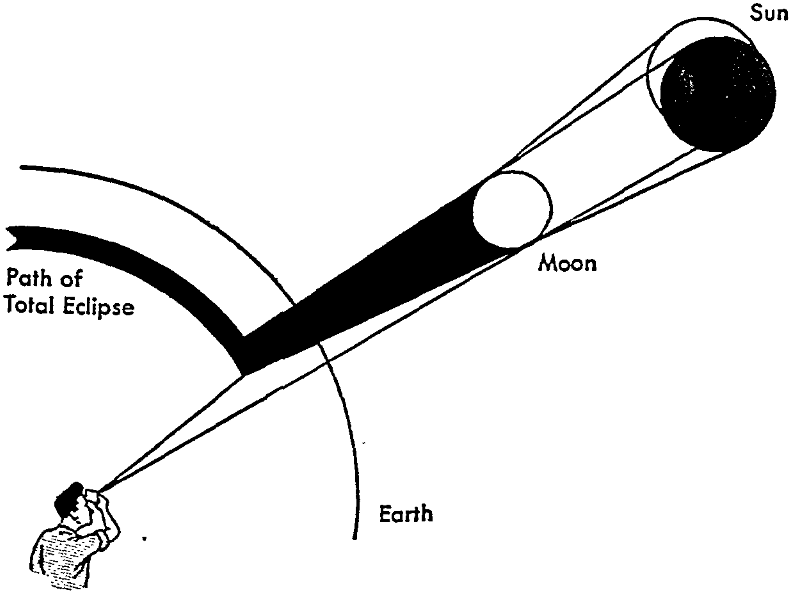
Eclipses are predicted by astronomers many years in advance. Not only are the date and year predicted, but the hour, minute, and exact second when they will start and end. In 1950, a total eclipse took place Its path and timing were

[1]Data from *Science News Letter*, July 30, 1932.

known in advance. Government scientists set up a laboratory on Attu, an island off Alaska. This eclipse was thoroughly studied with radio equipment. The equipment, called *radar*, measured the amount of radiation cut off as the shadow of the moon moved across the sun. One great advantage of radar equipment is that it can record information even though the sky is cloudy. Telescopes can be used only in clear weather.

Although the 1950 eclipse lasted only 73 seconds, scientists spent months in setting up and testing their equipment. Each observation was practiced, so that the timing would be just right. Much new knowledge was to be gained in that brief time, so not one second could be wasted. The careful planning produced excellent results.

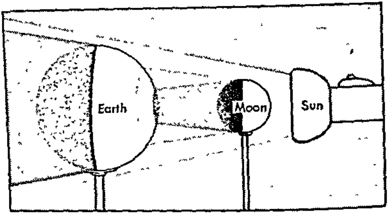
The 1950 eclipse was not even seen as a partial eclipse in the United States. Its path was far out in the Pacific. The 1945 eclipse, however, was seen by many people. Those who did not see it as total were able to see it as a partial eclipse. This is shown in the diagram below.



Cause of a Partial Eclipse.—A person in the band marked "Path of Total Eclipse" would see a total eclipse of the sun. The figure in this diagram sees a partial eclipse. Study the diagram, imagine this happening, and then explain how a partial eclipse is caused.

EXPERIMENT 15

What causes an eclipse of the sun?



Compare this drawing with that for Experiment 14. In this case it is the smaller body—the moon—that shuts off the light of the sun. That is why the shadow is cone-shaped, making a small shadow on the earth. Notice the darker shadow and the lighter shadow on the drawing. As in Experiment 14, the sizes and distances of the objects are out of proportion. Try to illustrate the distance on the blackboard. Let one-half inch equal 240,000 miles (earth to moon), and one hundred ninety-four inches equal 93,000,000 miles (earth to sun).

WHAT TO USE.—Use the same apparatus as in the preceding experiment.

WHAT TO DO.—Think out for yourself how to arrange the golf ball, baseball, and flashlight to cause a shadow of the "moon" to be cast on the "earth."

WHAT HAPPENS.—Make a drawing to illustrate what happens.

CONCLUSION.—What causes an eclipse of the sun?

APPLICATION.—Using a pencil, an electric light bulb, and a piece of paper, demonstrate the cause of the shadow's having a darker and lighter portion.

As the moon, invisible in the bright light, comes between the observer and the sun, it appears through a smoked glass as a dark circular object. It makes a curved nick in the edge of the sun. As the moon covers more and more of the sun, the world grows dark with a weird disappearing light. The shadow of the moon moves across the earth at a speed of 2000 miles per hour. Animals prepare for the night, stars and planets shine. When the sun's disk is all covered, flames of hydrogen and other gases flash from behind and form a lighted corona.

LIBRARY RESEARCH

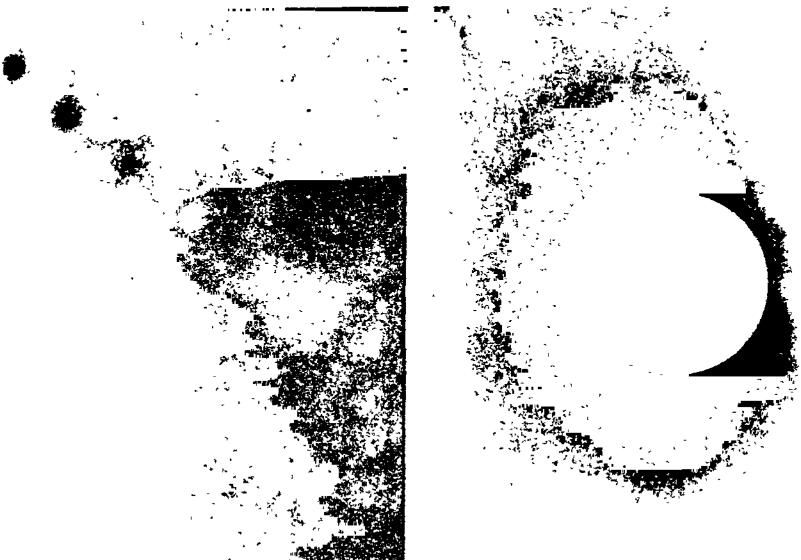
Look up some records of early eclipses. Try to find out about the one which brought an end to a five-year war on May 28, 585 B.C. How can we be so certain about this date?

Report your findings to the class.

You will be interested to try Experiment 15 to demonstrate just how the sun is eclipsed or hidden by the moon. Recall also what was said about Experiment 14.

Solar Eclipse.—An eclipse of the sun always goes from its west side to its east side. (Left) At top, the moon begins sliding in front of the sun. (Right) At totality, only the hot gases surrounding the sun can be seen.

Courtesy Mt. Wilson Observatory



Courtesy Mt. Wilson Observatory

New Moon

First Quarter (two stages)

Where is the sun in relation

FIELD RESEARCH

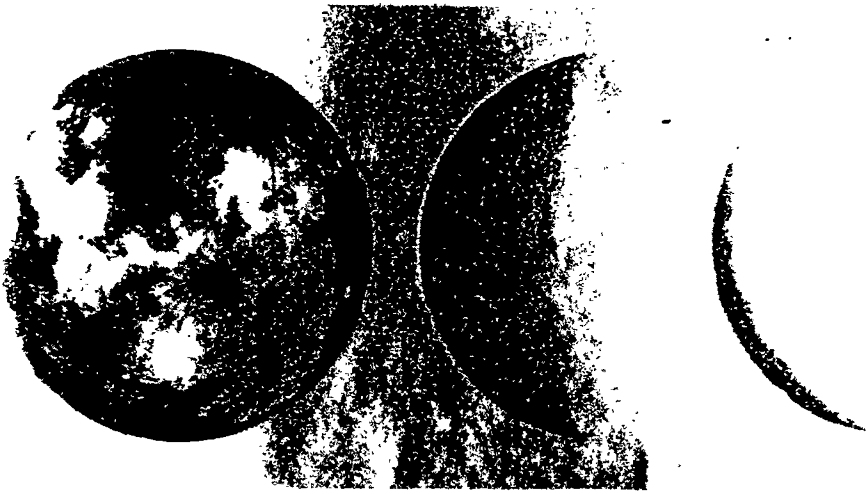
If you are fortunate and witness an eclipse of the sun, you may try the following Observe the eclipse of the sun through a smoked glass. Never look directly at the sun with the naked eye, because of the danger of injury to the eyes Smoke a piece of glass by setting fire to a very small piece of camphor gum placed on a piece of sheet iron or asbestos. Camphor gum burns with a low temperature and produces a very dense smoke The flame can be extinguished by blowing on it. You may also use a burning candle to smoke the glass

Look at the sun through the smoked glass during the eclipse. You will see the shape of the moon silhouetted against the face of the sun. The shape will be circular. What does this prove?

Another observation to make before and during an eclipse of the sun is to note, as the sunlight shines through tiny openings of the leaves of trees, the shape of the lighted areas where the sunlight falls. Usually these areas are circular in shape. During a solar eclipse, the shape is crescent This is because part of the light is cut off by the moon and the spaces through the leaves are small enough to act like a hole of a pinhole camera to reproduce an image of a bright object.

THE PHASES OF THE MOON.—Why is the moon full? Why is there a half moon? Have you wondered about these things on clear moonlit nights and tried to think out the answers? They are not difficult to answer, if you will do some straight thinking.

The bright side of the moon is always toward the sun.



Courtesy Mt. Wilson Observatory

Full Moon Third Quarter (two stages)

to each phase of the moon?

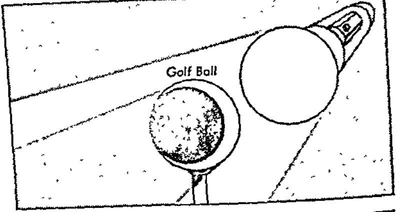
Now, since the moon travels around our earth, some of the time the whole lighted face is toward us and sometimes only part is visible. As you read about the phases of the moon in the next paragraph, be sure to refer to the diagram on page 170.

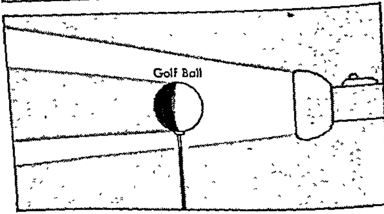
These apparent shapes of the moon are called *phases*. The *phases of the moon* in order of appearance are called: *new moon, first quarter, full moon,* and *third quarter*. These names really tell us how much of the moon's journey around the earth is completed each month. Starting with the thin crescent of the new moon, the completion of the first quarter of the journey is indicated by a half moon. The full moon tells us the journey is half over. The third quarter marks the finish of the third quarter of the journey. With the next new moon the complete journey has been made and a new one started. The whole journey, as you know, takes nearly 29 days.

New Moon.—As the earth and moon move, the sun, moon, and earth regularly fall into a nearly straight line, with the sun beyond the moon as we look at it. At such times the bright face of the moon is away from us. This phase is the new moon. Usually the moon cannot be seen now. (Diagram, page 170.) With certain atmospheric conditions, however, the new moon is faintly visible. It may be lighted by sunlight reflected from the earth. This is sometimes called the "dark of the moon."

EXPERIMENT 16

What causes the phases of the moon?





In this experiment you will need to watch carefully to see just how it illustrates the phases of the moon As the experiment is tried, keep the sun and moon in your mind as you have seen them. Do you usually see the sun at the same time you see the moon? Why?

In all of these experiments with the "sun," "earth," and "moon," keep in mind what kind of energy is being used

WHAT TO USE.—A darkened room, table, golf ball with support; and a flashlight

WHAT TO DO.—1. In the darkened room place the golf ball on its support on a table in front of the class With the flashlight behind the g[illegible] flashlight so that the light shines on the ball and

2. Keeping the light shining on the golf ball, move the flashlight to the left (counter-clockwise) until it is at the left of the ball and shines on it parallel to the front of the class.

While moving the light, notice how much of the lighted part of the golf ball you can observe—first a narrow crescent and then a half of the ball.

3. Continue moving the flashlight counter-clockwise until it is in front of the class and shines directly on the ball. Again notice how much of the lighted surface is visible.

4. Continue moving the flashlight around the ball, keeping its light falling on the ball until it is at the right of the ball and finally at the place of beginning.

Make a labeled drawing to illustrate each step in the experiment.

WHAT HAPPENS.—1. What part of the golf ball was lighted? Could you see that part from where you sat? What phase of the moon did this position illustrate?

2. How much of the ball's surface was lighted? Could you see that much or only a smaller portion of it was lighted? What shapes did the lighted portion take? What phase of the moon did this position illustrate?

3. How much of the surface of the ball was now lighted? Could you see all of the lighted surface? What phase of the moon did this position illustrate?

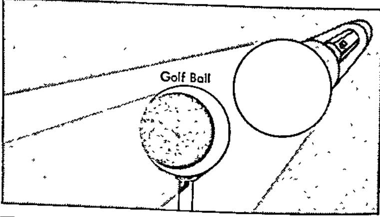
4. Describe what you saw. What phase of the moon did this position illustrate?

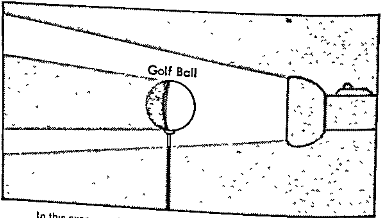
CONCLUSION.—How much of the ball's surface was lighted all of the time? Could you see that much of the lighted surface all of the time or only portions? Why?

What is the cause of the apparent change in shape of the moon?

As the earth and moon journey on, the sun's rays strike the moon at an angle from our right, and we see a small strip of crescent-shaped light on the moon. This thin crescent is often called the new moon. Actually the moon is already past the new moon phase when a crescent is seen. When the thin crescent appears on a clear night, we can often see a faint outline of the entire moon. Some people call this the "old moon in the arms of the new moon." The crescent is that part of the moon lighted by rays coming directly from the sun. The faint outline of the rest of the moon is the part lighted by the sun's rays reflected from the earth.

What causes the phases of the moon?





In this experiment you will need to watch carefully to see just how it illustrates the phases of the moon As the experiment is tried, keep the sun and moon in your mind as you have seen them. Do you usually see the sun at the same time you see the moon? Why?

In all of these experiments with the "sun," "earth," and "moon," keep in mind what kind of energy is being used

WHAT TO USE —A darkened room, table; golf ball with support; and a flashlight

WHAT TO DO —1 In the darkened room place the golf ball on its support on a table in front of the class With the flashlight behind the golf ball, point the flashlight so that the light shines on the ball and toward the class

2. Keeping the light shining on the golf ball, move the flashlight to the left (counter-clockwise) until it is at the left of the ball and shines on it parallel to the front of the class.

While moving the light, notice how much of the lighted part of the golf ball you can observe—first a narrow crescent and then a half of the ball.

3. Continue moving the flashlight counter-clockwise until it is in front of the class and shines directly on the ball. Again notice how much of the lighted surface is visible.

4. Continue moving the flashlight around the ball, keeping its light falling on the ball until it is at the right of the ball and finally at the place of beginning.

Make a labeled drawing to illustrate each step in the experiment.

WHAT HAPPENS.—1. What part of the golf ball was lighted? Could you see that part from where you sat? What phase of the moon did this position illustrate?

2. How much of the ball's surface was lighted? Could you see that much or only a smaller portion of it was lighted? What shapes did the lighted portion take? What phase of the moon did this position illustrate?

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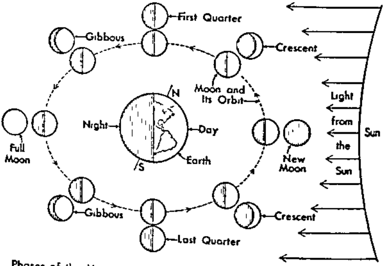
FIRST QUARTER.—As days pass, a night comes when the sunlight strikes the moon squarely from our right as we look toward it. We see the half circle of light (half moon). The first quarter of the moon's journey about the earth is completed.



Phases of the Moon.—This diagram shows the earth, light from the sun, and two rings of moons. The inside ring shows what the moon would look like if you were viewing it from some place off in space. Note that half of the moon is always lighted—the half facing the sun. The outside ring of moons shows the portion of the moon's lighted face you see when on the earth. These are the *phases of the moon.* The dark portion of the moon (the part you cannot see) is represented by shading in the diagram. According to the diagram, you cannot see the *new moon.* Why not?

FULL MOON.—When the sun is shining on the opposite side of our earth, leaving us in darkness, you may, at the right time of the month, see the full face of the moon. It is lighted by the light rays from the sun which pass by and beyond our earth and strike the moon. As you stand facing a full moon, the sunshine is coming from behind you, passing a little above or below the earth.

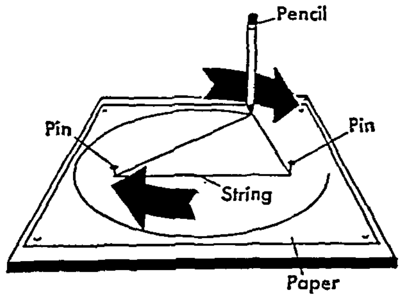
THIRD QUARTER.—When the sunlight comes from your left as you face the moon, half of its lighted face is visible. This marks the third quarter of the moon's journey. Here the sun and moon are again at right angles to each other with reference to the earth. Whether the moon looks "full," "half," "quarter," or crescent-shaped, actually half of it is lighted by the sun. You see only part of the lighted surface. This is why the moon appears to change shape, although you know now that it really does not.

If you see all of the lighted surface of the moon, it is circular in shape and called *the full moon*. If you see only half of the lighted surface from one side, it looks like a half circle (half moon). You cannot see the part not lighted. With the change from "new" to first quarter, the moon appears crescent-shaped. You can tell where the sun is in relation to the earth and moon because the horns of the crescent point away from the sun.

Study the diagram on page 170 carefully. Then try Experiment 16 to demonstrate the phases of the moon.

THE ORBIT OF THE MOON.—In making your outdoor observations of the phases of the moon, the earth on which you stand appears to stand still. The moon and the sun seem to move. Is this what really happens? In Experiment 16 the "moon" was kept in the same place. You stood in the same place while the "sun" was moved. Of course actually the moon and the earth both move. The earth moves around the sun, while at the same time the moon moves around the earth.

The path of the moon about the earth is called the *moon's orbit*. Likewise the path of the earth about the sun is called the *earth's orbit*. The moon's orbit is nearly circular. The earth's orbit, however, is elliptical; that is, one diameter is longer than the other. The path itself forms an *ellipse*, that is, a somewhat oval figure. (It would be well to practice drawing an ellipse, using a string, two pins, your pencil, and paper as shown in the diagram.)



How to Draw an Ellipse.—Be careful to keep your pencil straight up and down. Why?

The orbit of the moon and of the earth are not perfectly straight with respect to each other. If we could look at both orbits from far off in space, we should see that they cross each other. In other words, part of the earth's orbit is a little above part of the moon's orbit. And the other part is a little below a part of the moon's orbit.

Eclipses are due to the fact that *the orbits of the earth and the moon are tipped with respect to each other.* This is also why the moon rises and sets at different positions along the horizon during the year.

THINKING THINGS OVER.—In this topic we have been studying about the largest and one of the smallest bodies in our solar system. Can you picture in your mind's eye how large the sun is? Can you picture it as a tremendous mass of hot swirling gas? Can you understand how much energy the sun sends out? And how little of it reaches the earth? Yet this little bit means the difference between life and death on the earth. Can you explain that?

The moon is not a very large body. Its diameter is less than the distance across the United States. Yet, even though small, it is perhaps the most familiar of all the heavenly bodies. We know that conditions on the moon are much different than on the earth. Without air, the moon is a barren mass of rock. It is very, very hot by day, and very, very cold by night.

The motions of the moon around the earth, and the earth around the sun, cause eclipses. Can you explain how an eclipse of the sun happens? Do you know what causes an eclipse of the moon?

In our next topic we shall visit some of the planets of the solar system. Then we shall go beyond the planets, far out into space.

KEY WORDS

atmosphere
crescent
eclipse
ellipse
energy
force
gravitation
horizon
illuminate
moon
orbit
phase
planet
radiation
reflect
revolution
rotation
solar system
space
sun spot
telescope

Key Statements

1. The sun is the largest body in our solar system.

2. The planets revolve around the sun in the same direction, all in fixed courses, but at different distances from it.

3. The force of gravity is greater on a large, heavy body than on a small, light one.

4. Directly or indirectly, practically all of the energy used on earth comes from the sun.

5. The sun, the nine known planets, and the many small bodies revolving about the sun make up the solar system.

6. Sun spots are caused by terrific storms in the atmosphere of the sun.

7. Radio, Northern Lights, and world weather conditions are related to sun spot activity.

8. Moonlight is sunlight reflected by the moon.

9. The moon belongs to and revolves about the earth.

10. The moon is a small, cold body without an atmosphere.

11. An eclipse of the moon occurs when the earth is directly between the sun and the moon. The shadow of the earth passes over the face of the moon.

12. The shadow of the earth on the moon is circular. This helps to prove that the earth is round.

13. An eclipse of the sun occurs when the moon is directly between the sun and the earth.

14. Eclipses can be predicted many years in advance because scientists know the paths taken by the sun, moon, and earth and how fast they move.

15. The different phases of the moon are due to the different amounts of the moon's lighted portion we see.

16. The four phases of the moon are called new, first quarter, full, and third quarter.

17. The new moon occurs when the moon and sun are in line with the observer,—the sun behind the moon.

The full moon occurs when the sun and moon are opposite each other, that is, when the moon is in front and the sun is behind the observer.

The first and third quarters occur when the sun and moon in their revolutions take up positions at right angles to each other with reference to the earth.

18. An orbit is the path traveled by a planet or other celestial (heavenly) body around a central object.

orbits from far off in space, we should see that they cross each other. In other words, part of the earth's orbit is a little above part of the moon's orbit And the other part is a little below a part of the moon's orbit.

Eclipses are due to the fact that *the orbits of the earth and the moon are tipped with respect to each other*. This is also why the moon rises and sets at different positions along the horizon during the year

THINKING THINGS OVER —In this topic we have been studying about the largest and one of the smallest bodies in our solar system. Can you picture in your mind's eye how large the sun is? Can you picture it as a tremendous mass of hot swirling gas? Can you understand how much energy the sun sends out? And how little of it reaches the earth? Yet this little bit means the difference between life and death on the earth. Can you explain that?

The moon is not a very large body. Its diameter is less than the distance across the United States. Yet, even though small, it is perhaps the most familiar of all the heavenly bodies. We know that conditions on the moon are much different than on the earth. Without air, the moon is a barren mass of rock. It is very, very hot by day, and very, very cold by night.

The motions of the moon around the earth, and the earth around the sun, cause eclipses. Can you explain how an eclipse of the sun happens? Do you know what causes an eclipse of the moon?

In our next topic we shall visit some of the planets of the solar system. Then we shall go beyond the planets, far out into space.

KEY WORDS

atmosphere	horizon	reflect
crescent	illuminate	revolution
eclipse	moon	rotation
ellipse	orbit	solar system
energy	phase	space
force	planet	sun spot
gravitation	radiation	telescope

Key Statements

1. The sun is the largest body in our solar system.

2. The planets revolve around the sun in the same direction, all in fixed courses, but at different distances from it.

3. The force of gravity is greater on a large, heavy body than on a small, light one.

4. Directly or indirectly, practically all of the energy used on earth comes from the sun.

5. The sun, the nine known planets, and the many small bodies revolving about the sun make up the solar system.

6. Sun spots are caused by terrific storms in the atmosphere of the sun.

7. Radio, Northern Lights, and world weather conditions are related to sun spot activity.

8. Moonlight is sunlight reflected by the moon.

9. The moon belongs to and revolves about the earth.

10. The moon is a small, cold body without an atmosphere.

11. An eclipse of the moon occurs when the earth is directly between the sun and the moon. The shadow of the earth passes over the face of the moon.

12. The shadow of the earth on the moon is circular. This helps to prove that the earth is round.

13. An eclipse of the sun occurs when the moon is directly between the sun and the earth.

14. Eclipses can be predicted many years in advance because scientists know the paths taken by the sun, moon, and earth and how fast they move.

15. The different phases of the moon are due to the different amounts of the moon's lighted portion we see.

16. The four phases of the moon are called new, first quarter, full, and third quarter.

17. The new moon occurs when the moon and sun are in line with the observer,—the sun behind the moon.

The full moon occurs when the sun and moon are opposite each other, that is, when the moon is in front and the sun is behind the observer.

The first and third quarters occur when the sun and moon in their revolutions take up positions at right angles to each other with reference to the earth.

18. An orbit is the path traveled by a planet or other celestial (heavenly) body around a central object.

Thought Questions

1 You have learned that the weight and size of the sun are tremendous in comparison with those of the earth. What are some of the results of the great size and weight of the sun?

2 About how heavy do you think this book would be if the earth were as large as the sun? How heavy do you think the book would be if the earth were as small as the moon?

3 Our sun is the great powerhouse upon which all life on the earth depends Explain how the electric energy which is produced at Niagara Falls and at other great waterfalls really comes from the sun

4 You know that the moon is a cold and lifeless body with absolutely no light of its own Yet the bright moon is one of the most beautiful sights in the sky. How is it that we can see the moon at night?

5 Do you believe that our earth reflects the light which comes to it from the sun? Collect the facts carefully, for like any good scientist you should be able to give good evidence for your statements.

6 Why is the force of gravity so much less on the moon than it is on the earth? What are some of the conditions on the moon which result from the small force of gravity there?

7 The thick, protective atmosphere on our earth is very important to us in a great many ways What do you think would happen if there were no atmosphere on the earth?

8. There are no absolutely black or dark shadows to be found on the earth Can you explain why this is so? Again be able to support your answer with good scientific reasoning

9. Most of us love to take imaginary journeys through the great spaces of our solar system How long do you think it would take a rocket travelling at 3600 miles per hour to reach the moon?

10. You should now be able to explain very clearly what causes an eclipse of the moon Of course, you can also explain just how it is that an eclipse of the sun occurs

11. You have a good understanding now of the movements of the sun, moon, and earth through the heavens On the basis of this knowledge, explain why there is not an eclipse of the moon and sun every month.

12 It's fascinating to watch the nightly changes in the shape of the moon as it waxes and wanes However, does the shape of the moon really change? Explain your answer carefully.

Projects for Your Science Discovery Book

1. Make a list of the activities that would be impossible if the earth were as large as the sun, and tell why.

2. List six ways in which you are dependent directly or indirectly upon the energy from the sun.

3. Through a small telescope or powerful field glass observe the moon when it is crescent-shaped and when it is full. Make drawings of what you see.

4. Observe the phases of the moon over a month's time and record drawings and observations.

5. Learn how to make a pinhole camera to demonstrate the shape of images of bright objects.

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Courtesy Mt. Wilson Observatory

Saturn and Its Rings.—Modern telescopes bring our solar neighbors close for observation and study. This is how Saturn looks through a telescope. The rings of Saturn are made up of millions of tiny bits of matter or moonlets. Each one reflects sunlight.

TOPIC VII

The Planets and Out Beyond

DO YOU KNOW—

1. How far the 200-inch telescope can "see"?
2. How to tell a planet from a star?
3. That the Evening Star is not a star?
4. What causes the tides?
5. What a galaxy is?

GENERAL PROBLEM 1

What Are the Family Traits of the Planets?

THE SUN'S FAMILY.—Anyone who watches the constellations, from night to night, has occasionally discovered a visitor in this or that group. These visitors shine with a clear, steady light in contrast to the twinkle of the surrounding stars. They seem to move across the constellations, sometimes from east to west, sometimes from west to east. Their name, *planet*, comes from an old Greek word meaning "wanderer."

The real stars of the heavens do not visibly change their positions in relation to each other. That is why they are sometimes called *fixed stars*. The planets, on the other hand, do change their positions in relation to each other and in relation to the stars. The paths (orbits) of the planets are as well known to astronomers as are the orbits of the sun and moon.

These scientists can tell you just when and where you can observe them. Some planets are visible in the summer months, others in other seasons

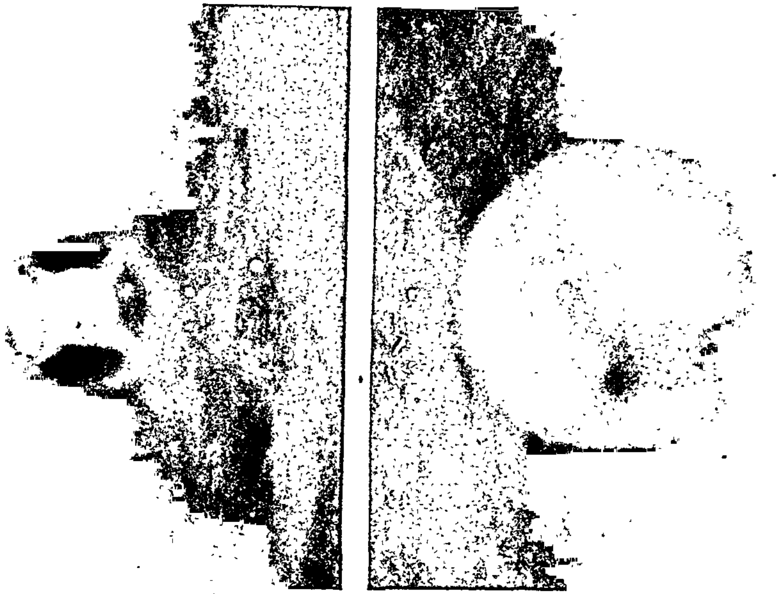
Some of the planets look much brighter than the stars. That is because they are so much nearer and because their surfaces are good reflectors of light. All of the planets are cold bodies They can be seen only because they are illuminated by light from the sun In this respect the planets are like the moon.

In the order of their distance from the sun, the nine known planets in the sun's family are *Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune,* and *Pluto.* There are also about one thousand very small bodies called *planetoids* (little planets) revolving around the sun. They are of little importance

LONG AND SHORT JOURNEYS --In ancient times men thought that the sun and all the other bodies in the heavens revolved about the earth. But we know this is not so. Instead, the earth and the other planets move around the sun. It takes 365¼ days for the earth to make its journey around the sun. Mercury, the smallest of the planets and the one nearest to the sun, completes its revolution in 88 days. Neptune, nearly 2800 million miles from the sun, requires 165 of our years for one revolution In other words, Neptune's year is 165 times longer than a year on the earth Pluto, the most recently discovered planet, requires almost 248 times as long to make one complete revolution about the sun as does the earth. These planets are all revolving around the sun in about the same plane as the earth

"THE RED PLANET."—Mars is the planet about which we hear most. It is about one and one-half times as far from the sun as the earth. It takes 687 days for Mars to revolve once around the sun. This means that a year on Mars (reckoned in our time) is nearly twice as long as a year on the earth.

In some respects the earth and Mars are alike. It is probable that Mars has a thin layer of gases or atmosphere. It is known as "The Red Planet" because of the color of light which it sends out. There seems to be plant life on Mars, but just what kind is not definitely known by scientists. Both the earth and Mars are cold bodies, receiving heat and light from the sun. Since



Solar Neighbors.—The planet Uranus (left) has five moons. The ring is not like the rings of Saturn, but was caused in taking the picture. Mars (right) shows dark areas which may be vegetation. The color of these areas seems to change regularly with the changing seasons on Mars.

Mars is farther from the sun than is the earth, it receives less heat than the earth. Its surface temperature ranges from 90° F. below zero to about 60° F. above zero. Plant life therefore, if any exists there, must be unlike that of the earth. Since it has less atmosphere than our earth and probably little oxygen or water vapor in it, animal life, if there is any, would also differ from that on earth.

Mars rotates on its axis once in a little more than $24\frac{1}{2}$ hours; so the length of day is not very different from our day. Mars has two moons while our earth has only one.

THE KING OF PLANETS.—Jupiter is a planet a thousand times larger than the earth. Although Jupiter is 88,392 miles in diameter, it is so far away that it looks like a small star. The moon, on the other hand, looks large, even though it is only 2160 miles in diameter. This is because it is so near—only 240,000 miles away.

Twelve moons have been discovered revolving around Jupiter. The moon nearest to Jupiter takes only about eleven hours

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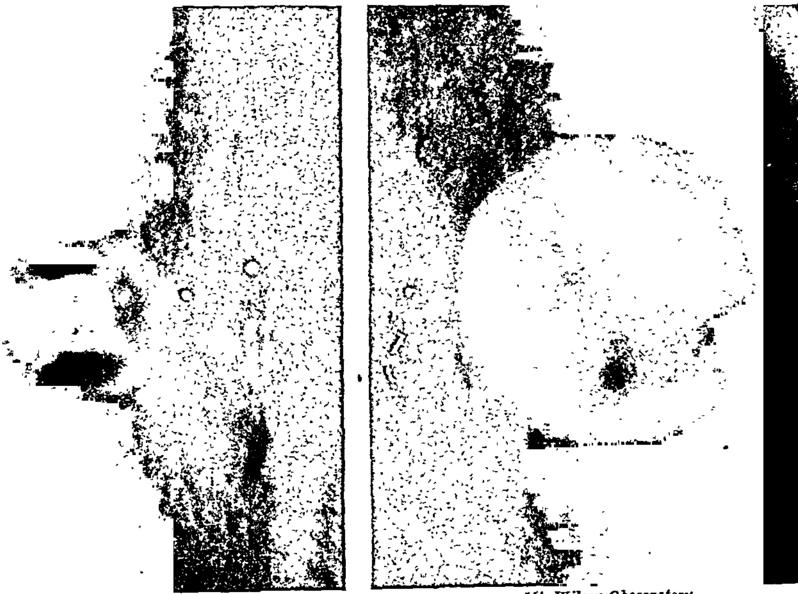

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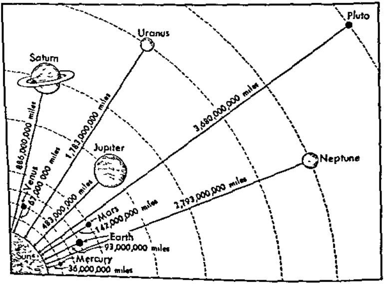
Twelve moons have been discovered revolving around Jupiter. The moon nearest to Jupiter takes only about eleven hours to make one revolution Four of these moons can be seen with a small telescope. Galileo discovered them first with his new telescope in 1610. The twelfth moon was discovered in 1951.

FIELD RESEARCH

Secure a small telescope or good field glass. Arrange to steady it on a support Then when Jupiter is in a good position for observation, try to discover the four moons that Galileo saw.



The Solar System.—How many known planets are there? Which one is nearest to the sun? Which planet do you think is coldest? Do you know which planet is the "earth's twin"? Is there life on Mars?

There is evidence that Jupiter has a dense, deep atmosphere, full of yellow and red clouds. The atmosphere is different from ours in that it contains ammonia and methane. You are familiar with ammonia, as it is used for household cleaning. Methane is a gas that is sometimes formed by decay of vegetation under water. It is given off as bubbles when the mud at the bottom of the pond is disturbed.

clouds. It is nearer the sun than the earth, being only about 67,000,000 miles from the sun We rarely see Venus overhead in the night sky, for it never gets very far from the sun It appears at twilight in the western sky, or just before dawn in the eastern sky You will understand these statements better if you turn back to the diagram on page 180. Notice how Venus will always be close to the sun. When Venus is on the same side of the sun as the earth, and nearer to the earth, it shines with great brilliancy It is so bright that at times it can be seen for awhile even after sunrise, or before sundown.

Alike as Venus and the earth are, their atmospheres are very unlike. Water and oxygen, so necessary to earthborn creatures, are very rare on Venus. That fact seems to prove that there is no life there. Life, as we know it, must have oxygen.

MORNING AND EVENING "STARS."—Parading ahead to herald the rising sun, Venus is a sight well worth our getting out before sunup to see. At certain seasons this beautiful planet seems to be leading the sun across the sky. We cannot see it in the evening sky, because it sinks below the horizon before the sun does But it rises in the east just before the sun in the morning. At these times, Venus is called the Morning Star.

Then, as the planets change their positions, Venus may follow the sun across the sky Then it can be seen in the west soon after sunset. At this time it is called the Evening Star. But Venus appears to lose a little in the race every day. Thus it sets later and later after the sun until it becomes a Morning Star again.

It will help to understand this if you again refer to the diagram on page 180. Venus is revolving about the sun inside the orbit of the earth Therefore we see it part of the time to the right of the sun, that is, west of the sun. From the earth it seems to move ahead of the sun in its path. Thus it rises ahead of the sun and is a Morning Star. However, a little later Venus appears to the left of the sun, that is, east of the sun. Then it seems to follow the sun and hence sets later than the sun. It is then the Evening Star.

MERCURY.—There is another Evening Star which may be seen in the spring, very soon after sunset. It is Mercury, the planet closest to the sun. *Mercury is so near to the sun that it* is only seen near the horizon soon after the sun sets or just before the sun is up in the morning. In February of 1940 Mercury led Venus, Jupiter, Saturn, and Mars in a sky parade not seen before for many hundreds of years. Because of its nearness to the sun, the Greeks believed that Mercury was a close friend of Apollo, the sun-god.

Mercury is much smaller than the earth. It is only about the size of the moon. Because of its nearness to the sun and lack of atmosphere, it would be an uncomfortably hot place in which to live. It turns on its axis at about the same rate of speed that it moves around the sun. *This means that the same side is* always exposed to the sun's heat. The side toward the sun may be 660° F. This is hot enough to melt lead. The side away from the sun may be almost 460° F. below zero.

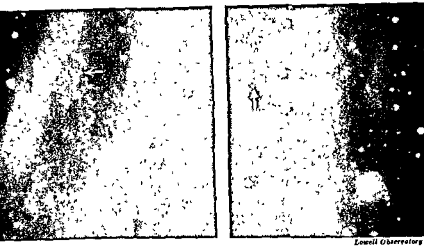
Saturn, the Ringed Planet.—One of the most beautiful sights of the heavens through a telescope is Saturn with its famous rings. Saturn is about ten times larger than our earth. But it is about as heavy as an equal volume of cork.

There are three rings around Saturn that make it look so different from the other planets. The middle ring is about 16,000 miles wide. The outside rings are about 10,000 miles wide. *These rings that look flat and thin are really made up* of vast numbers of small moons revolving around the planet. Besides the countless little moons of the rings, Saturn has nine regular moons.

It takes Saturn about twenty-nine times as long as the earth to make one revolution. Sometimes the planet is tipped so we can see the rings on edge. Most of the time, however, we can see the surface of the rings.

While a year on Saturn is about twenty-nine times as long as a year on earth, day and night are much shorter. This is because Saturn turns on its axis once in about ten hours instead of our twenty-four hours.

Is there life on Saturn? Saturn is more than 880,000,000 miles from the sun. *The earth, you know, is only about* 93,000,000 miles from the sun. How cold do you think it would be on a planet that *is nearly ten times farther from the sun* than the earth?



Lowell Observatory

The Newest Planet—The arrow points to Pluto. The picture on the right was taken six days after the other. The fact that Pluto had changed its position in the meantime proved that it was a planet, not a star, as astronomers previously believed.

PLUTO.—The planet Pluto is the most recent addition to the solar family. It was discovered in March, 1930. Its existence and position, however, had been predicted fifteen years earlier by Professor Percival Lowell of the Flagstaff Observatory, Arizona.

Pluto is nearly forty times as far from the sun as is the earth. It is so far away from the earth that it takes from four to five hours for its light to reach us. It requires almost 248 of our years for Pluto to make one revolution about the sun. In size Pluto is thought to be about 3,550 miles in diameter.

About a hundred years ago the planet Uranus was thought to be the most distant planet of the sun's family. However, scientists knew the paths planets should take as determined from their size, weight, distance from the sun, and other properties. They found that Uranus, for some reason or other, did not move in the particular path they thought it should. Two young scientists decided there must be another planet outside of Uranus which exerted gravitational forces upon Uranus. This, they believed, was causing Uranus to move in a different path than it would otherwise. Therefore, they assumed the presence of such a planet and calculated where it would be.

Later the planet Neptune was discovered almost exactly where these young scientists had predicted.

However, even the existence of Neptune was not enough to explain entirely why Uranus did not travel the path that it should. This led Professor Lowell to assume another planet still farther from the sun than Neptune. He calculated its position and how it would move. His calculations resulted in the discovery of Pluto.

The discovery of these two planets is an excellent example of the way in which scientists work in making new discoveries. Based on the motions of the planets already known, it depended on the laws of gravitation. It is striking evidence of the accuracy of the method of science.

ANOTHER PLANET?—Have all the planets of the sun's family been discovered? Or is there still another one? In 1950 some scientists predicted that there was still another planet, far out beyond Pluto. From a study of the orbits of the planets, they believe that this undiscovered planet is 77 times as far from the sun as is the earth. Are these scientists correct? No one knows right now. But the tenth planet may be discovered just as the 8th and 9th were.

MERRY-GO-ROUND.—Everyone knows that the sun and moon rise and set with perfect regularity. "As certain as the sun will rise" is an expression all of us have heard. As scientists, though, we should realize that the rising and setting of the sun and moon are apparent rather than real motions.

Have you ever had the experience on a train or automobile of thinking that a nearby car was moving when all the time the movement was that of your own car? In much the same way we can understand the *apparent* movement of the sun, the stars, the moon, and the planets from east to west in our sky.

The earth *rotates* (*turns*) *on its axis west to east*. Hence an object in the sky that is stationary in the sky pattern is seen first at the eastern horizon. As the earth continues to turn toward the east, the horizon line, where the sky and earth seem to meet, changes. The object appears to move upward through the sky, until it reaches a position directly overhead. As the earth turns still farther, the object appears to move closer to the western horizon. Thus the sun and the moon appear to move. Actually it is the earth which moves and thus causes the march of these bodies across the sky.

For the same reason, the stars at night appear to rise above our eastern horizon. They march across the sky, and finally sink below the western horizon. But it is only an apparent motion, since the earth during our night completes its rotation about its axis.

Planets are in almost the same plane with the sun and the moon. They therefore appear to rise nearly in the same position on the horizon as do the sun and the moon. They take nearly the same paths across the sky, and set at the western horizon. The stars each have their own parallel paths across our sky. Some, as you know, are above the northern horizon all the time. Of course another lot of stars have their paths above the southern horizon and are seen by people living south of the equator.

Star Trails.—To make this picture, a camera was pointed toward the North Star and the lens left open for eight hours. The camera moved with the rotating earth, and this caused each star to leave a trail on the film.

Courtesy Norman Lockyer Observatory

FIELD RESEARCH

Over a period of several months keep track of the place on the horizon where the sun and the moon rise or set. Try to explain why they do not rise and set at the same places on the horizon all year.

CATCHING UP WITH THE MOON.—You have learned that the moon not only turns on its own axis, but that it also revolves about the earth from west to east. Therefore, the motion of the moon is due to two causes: (1) apparent motion due to the rotation of the earth, and (2) the moon's real revolution about the earth. *Most of the moon's motion is apparent*, due to the earth's rotation. The stars and the sun, however, do not revolve around the earth. Thus the moon's motion will be different from that of the sun and stars.

The stars rise about four minutes (exactly 3 minutes 56 seconds) *earlier* each night. The moon rises about fifty minutes *later* each night. It takes twenty-four hours plus that fifty minutes for an observer at a given place on the earth to catch up with the moon and see it again at the eastern horizon. It is, therefore, fifty minutes later by the clock each night when the moon rises.

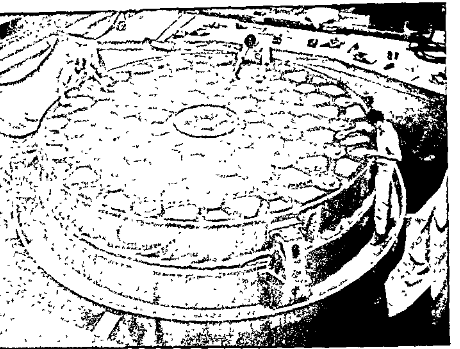
FIELD RESEARCH

Note the times given on a calendar for the rising of the moon each night and compare with your own observations.

GENERAL PROBLEM 2

What Is Beyond Our Solar System?

A TASK FOR YOUR IMAGINATION.—How far will your imagination reach? Are you satisfied to think of *our own* solar system with its planets? Or would you like to think *on and on and out* still farther beyond them into space? Will your imagination carry you out 1000 light years into space? A million light years? A *billion* light years?


O K Harter

Elbow Grease—These men are polishing the 200-inch pyrex glass disk of the Mt. Palomar telescope After the disk had been polished, it was coated with aluminum to make the mirror for the telescope.

THE ASTRONOMERS' TOOLS.—"How," you ask, "can anyone know what is a billion light years away from the earth?" And that is a good question. When we remember that one light year is about six trillion miles, we are staggered with the distance of a billion light years.

It is only in the last few years that astronomers have been able to explore these vast distances In 1924 a new 100-inch telescope at Mt Wilson opened up vast distances beyond the earth. But rather than solving the problems about the universe, this telescope merely showed that an even more powerful one was needed! Now, after more than twenty years of preparation, the new 200-inch Hale telescope on Palomar Mountain is reaching out a billion light years into space. The 100-inch and 200-inch refer to the size of the mirrors in these telescopes. Light from distant stars is gathered by the mirrors and focused onto a photographic plate. Thus astronomers do not *see* the far distant objects. They take pictures of them.

Mapping the Skies.—This is the 48-inch Schmidt telescope at Mt. Palomar. The astronomer is taking a sky picture for a photographic map of the universe. The "sky map" will take four years to complete and will guide astronomers for the next half century.

Wide World Photos

The 200-inch Hale telescope has a new team-mate also. It is the 48-inch Schmidt telescope. The Schmidt takes very clear pictures of a wide area of the sky. It is being used to map the entire sky, a job which should be completed by 1954. The sky maps are then studied. Any interesting objects are next photographed with the 200-inch Hale telescope. The Hale sees far; the Schmidt sees wide.

Our Galaxy.—The stars that you see are suns, many of them thousands of times larger than our sun. Scientists believe that all these suns and many more, too, form a great group, shaped like a huge lens, or perhaps like a wagon wheel. This group of stars, or island universe, is called a *galaxy*. A galaxy is a great system of suns having an orderly motion and development. The diameter of our galaxy is about 200,000 light years. Its thickness is about 20,000 light years. If you recall that one light year is almost six trillion miles, it will help you understand how huge our galaxy is. These dimensions are approximate only. So far it has been impossible to measure them accurately.

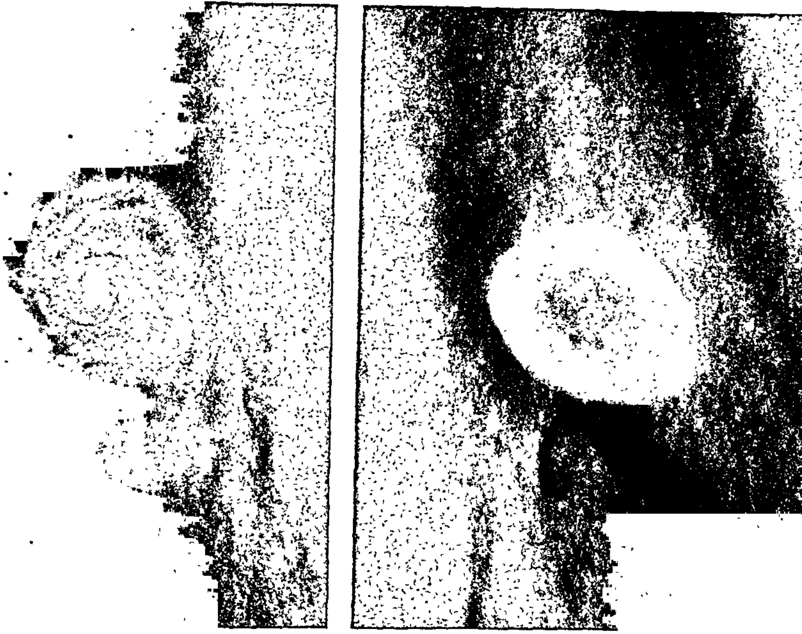
Our solar system is only part of our galaxy. The outer rim of this galaxy is the Milky Way. It is the same Milky Way

Great Spiral in Andromeda.—Photographs like this have helped astronomers make their wonderful discoveries about the universe. Galaxies like this were once thought to be gaseous nebulae. Now we know that many of them are really galaxies made up of great masses of stars.

we see as a band of faint stars across the sky. Our galaxy probably contains several hundred thousand million stars. One of these stars is our sun It is important to us but in the galaxy it is just another star The entire galaxy is rotating like a great wheel once in about 200,000,000 years. On this basis, our sun with its family of planets is traveling about 200 miles per second in its journey through space.

OTHER GALAXIES.—Our Milky Way galaxy is not the only galaxy. Far out in space are other galaxies. These other galaxies are so far away that even the Hale telescope cannot photograph their separate stars.

The new 200-inch telescope has given us fine pictures of the



Courtesy Mt. Wilson Observatory

Two Kinds of Nebulae.—The "spiral" nebula on the left looks like a great whirlpool in space. On the right is a "ring" or "planetary" nebula. Ring nebulae probably get their light from stars.

different kinds of galaxies in space. One kind is the *spiral* galaxy, such as our Milky Way galaxy. Another kind is the *globular* galaxy. Still another kind of galaxy is in the shape of an *ellipse.*

The brightest of our neighboring galaxies is the great *Andromeda galaxy.* On a clear moonless night you can see this galaxy with your naked eye. It is in the constellation Andromeda shown in the star maps, pages 136, 137. For a long time it was thought to be a mass of gas among the stars. Now, however, photographs have proved that it is a galaxy. This galaxy is about 800,000 light years away. It is probably about 40,000 light years from side to side. As a matter of fact, our own Milky Way galaxy and the Andromeda galaxy are really quite similar.

All told, thousands of galaxies have been discovered. Each one is an island universe in itself. Each one contains millions and millions of stars.

MASSES OF GAS.—We have learned that our galaxy and all

Courtesy Mt Wilson Observatory

A Spiral Nebula in Virgo.—This photograph was taken with the 200-inch telescope at the Palomar Observatory. The picture shows the nebula edge on. The word "nebula" means "mist" in Latin.

other galaxies are made up of many, many stars. Galaxies also have great masses of glowing gas called *nebulae* (singular, *nebula*) One such nebula can be found in the constellation Orion. The ring nebula (picture, page 191) is also in our galaxy. Astronomers believe that there are millions of nebulae. Many are in our galaxy. Many are in other galaxies. Some may be outside of any galaxy However, nebulae are not systems of stars. They are masses of glowing gas.

How Was the Universe Formed?—No one knows how the universe was started, or how old it is. However, from what astronomers have learned about the stars, they have developed scientific guesses or *theories*. Thus the past history of the stars is reasoned out from the happenings of the present. As a science pupil you are learning to distinguish fact from theories or guesses. As scientists discover new facts, they often have to change their theory. You, too, must be ready to change your opinions as new facts are learned As scientific instruments are improved and new ones invented, new facts are discovered.

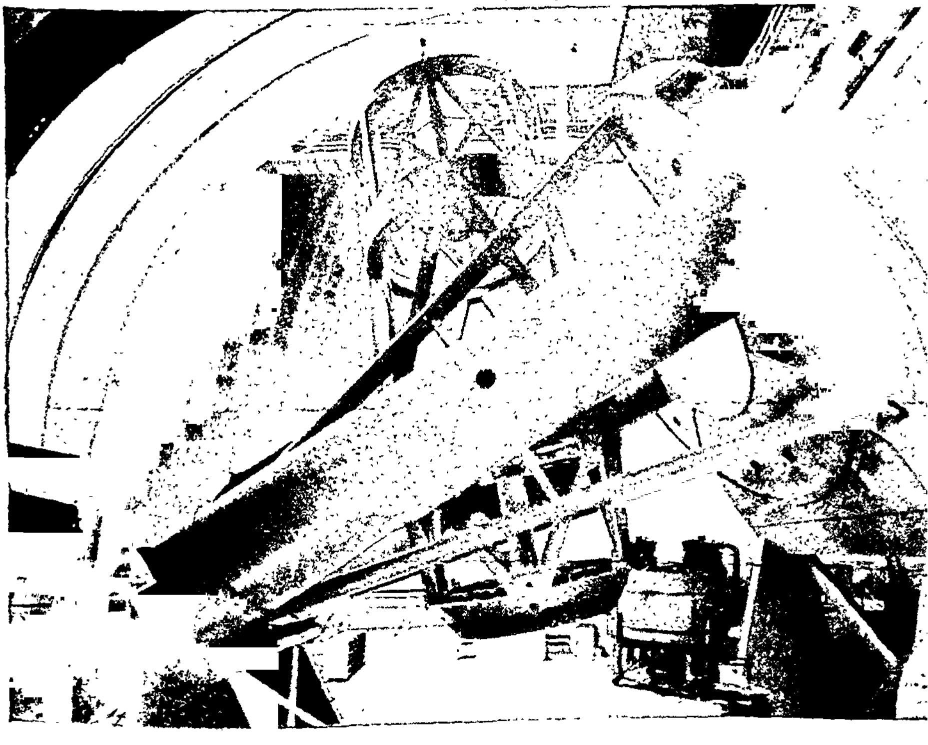
We have already mentioned two new telescopes now being used. It is possible that they will discover new facts and cause some theories to be changed. Earlier we read about the use of radar in studying eclipses of the sun. Who knows, perhaps radar will someday be a tool as important as the telescope in astronomy.

An Orderly Development.—We know that nature's activities today are carried on with systematic order. Many of these activities or happenings are known as natural laws. So it is thought that there has always been an orderly development throughout the ages. If this is true, it may very well be possible to reason out the happenings of the past from our knowledge of the happenings of today.

To tell the story of the development of the universe in a few simple sentences is impossible. It is like trying to paint a great

The 200-inch Telescope.—This shows the inside of the Palomar Observatory and its great telescope. With such instruments astronomers constantly learn more about the heavens. Scientific curiosity, however, will never be satisfied, and this telescope searches the sky every clear night for more knowledge.

Courtesy Mt. Wilson-Palomar Observatories



picture with one color or one line. All details and supporting evidence must be omitted. However, as you go on with your study of science you may find the evidence and detail for yourself. Perhaps you will discover the divine guidance in it all.

A Developing Universe.—According to one theory, about $3\frac{1}{2}$ billion years ago all the universe was one large mass of material—a sort of superatom. For some reason, this tremendous superatom exploded. The explosion may have produced millions of nebulae at great distances from each other. Or perhaps the explosion produced globular galaxies made up mostly of gas and dust. The nebulae started out as fluffy balls of gas, and gradually changed into clusters of stars or galaxies.

Another theory holds that the galaxies themselves are of different ages. The explosion of the superatom may have produced globular galaxies made up mostly of gas and dust. As they rotated, the dust formed into stars, and the galaxy flattened out. The continuing whirling caused streamers to be thrown off, and hence spiral galaxies were formed.

How did it all begin? How did it develop? Where will it all end? No one knows. But certainly it is a task for our imaginations. And as we think about the smallness of our own earth in this tremendous system, can we help but marvel at the order of it all?

GENERAL PROBLEM 3

What Holds the Universe Together?

Universal Gravitation.—Each one of the billion or more suns has a particular place in its own galaxy. Each one has some relation to all the other suns in that family. Out beyond, each galaxy has its place in the universe. The rules which produce this law and order in the universe have been known for many, many years by scientists. Early scientists knew that a stone falls to the earth because there is a *force of attraction* between the earth and the stone. They knew that unless the stone and earth are held apart by some equal or greater force they will come together. You know this to be true from your own experiences.

Archimedes knew this fact, and Galileo knew it. In fact Galileo made a special study of falling bodies. He learned that all bodies, large and small, fall at the same rate of speed for each second of time. He found, too, that they fall faster and faster each second. The farther they fall, the faster they fall.

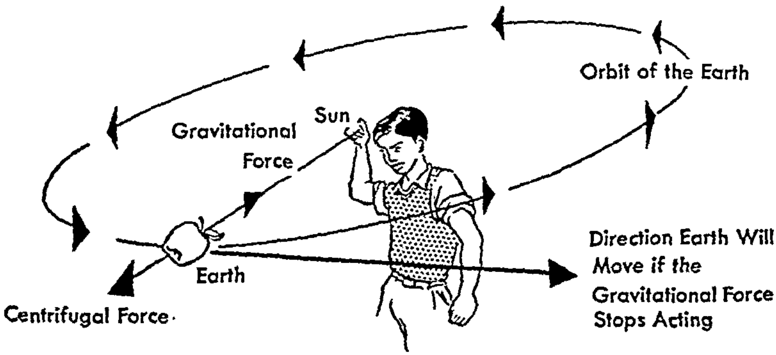
Sir Isaac Newton went much farther in his studies of gravitation. He proved to other scientists that the attraction which the earth has for the stone is a *universal attraction*. By that he meant *every body in the universe attracts every other body*. This is called *Newton's law of universal gravitation*.

All of the galaxies have an attraction or pulling force for each other. All of the suns have an attraction for each other. Our sun has an attraction for our earth and all the other planets. Our earth and all the other planets have an attraction for their moons.

HOLDING THE EARTH IN PLACE.—Newton's law helps explain how it is that the earth and the other planets maintain their positions in space while they travel about the sun.

The drawing below will help you to understand the forces that hold the planets in their orbits. As long as the string does not break, the apple will continue in its circular motion about your head as a center. Once it does break, the apple will fly off in a straight line.

In the same manner mud flies from the wheel of a rapidly



Balancing Forces.—Have you ever tried this experiment? Tell how *the forces illustrated here work opposite each other to keep the earth in its orbit.*

moving automobile or bicycle. The mud sticks to a slow-moving wheel. So long as the "sticking" force is greater than the "throwing" force, the mud will stay on the wheel. But as the wheel goes faster, the force which tends to throw the mud from the wheel increases The mud will fly off. The fact that the earth is revolving about the sun gives it a tendency to fly away from the sun just as the mud flies from the rotating wheel.

This force acting away from the center of a rotating body is known as centrifugal force The earth, revolving around the sun, is therefore acted upon by two balancing forces: *gravitation* and *centrifugal force* Gravitation tends to pull the earth and the sun together Centrifugal force tends to force the earth farther away from the sun. Because these forces are balanced, the earth maintains its position in its orbit.

All the other planets are also held in their places by a balancing of these two forces These same forces are also acting to maintain the orderly balance throughout the universe.

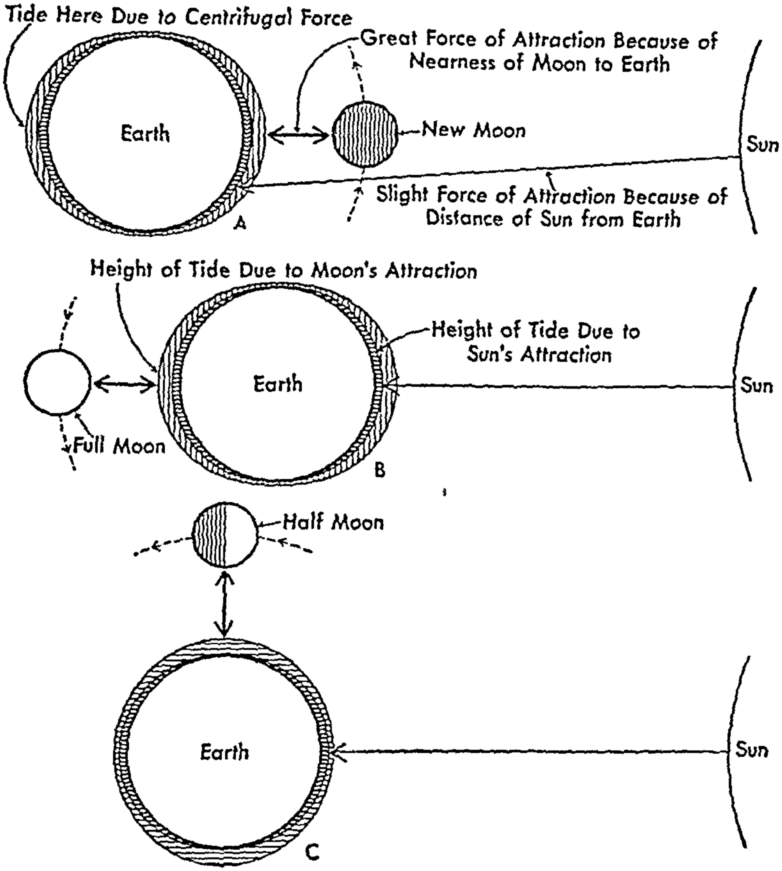
THE TIDES AND THE MOON.—One interesting result of the force of attraction and of centrifugal force is the ocean *tides*. The moon attracts and actually pulls the water of the ocean nearest it into a kind of heap or wave. See the diagram on page 197 As the earth turns on its axis, this wave follows the moon but lags behind about 200 miles each hour. Of course, heaping the water in one place must make it shallower in another Thus we have *high tides* and *low tides*.

Another curious fact about tides is that high tides occur in the ocean at the same time on the opposite side of the earth. This is due to the fact that the water, being farther away, is not attracted as much as the earth. The earth is actually pulled away from the water. The high tide on the side far from the moon is also partly caused by centrifugal force pushing the water away from the earth.

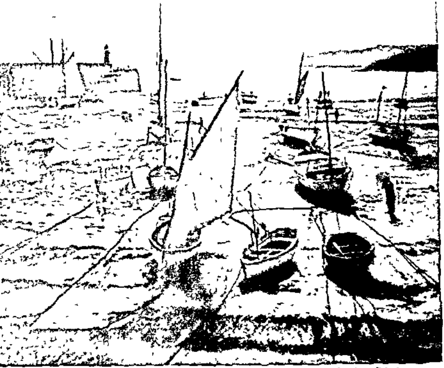
The sun, too, causes tides, but not as high as those caused by the moon That is because the sun is much farther away.

Since the earth turns on its axis once every 24 hours, a high tide occurs about every 12 hours. Each high tide at any given place is followed by a low tide 6 hours later.

THINKING THINGS OVER.—Can you now appreciate the gigantic scale on which our wonderful solar system is built? Yet you must not forget that the distances in our solar system are very small when we consider the distances to other suns in our galaxy. For example, you have read that Alpha Centauri is



Tides.—(A) Both the sun and moon are causing tides on the earth. The moon, being nearer, produces the greater effect. (B) Although on opposite sides of the earth, the moon and sun are still working together to produce the tide shown. (C) The moon and sun are pulling at right angles "against" each other. Note that the tide caused by the moon is greater than that caused by the sun. Explain why the forces of the sun and moon are added together in B. Why don't they, being on opposite sides of the earth, balance each other?



H Armstrong Roberts

Low Tide.—At a time like this all a fisherman can do is repair his boat and get ready for the next sail. This low tide is at St. Ives, England. Where else in the world is there a low tide at the same time?

over four light years away. The North Star is 1085 light years away. The galaxy in Andromeda is nearly one million light years distant

Your study of the universe reveals to you a law and order in nature almost beyond human understanding. As a student of science, you value facts. These facts should help you develop power to understand this gigantic universe of which our earth is such a little part. How small we humans are when compared to the universe! Yet we possess something that is greater, more wonderful, and more difficult to understand than all else in the universe. We have minds with which to think, and wills to direct our actions And we have souls to appreciate the grandeur of it all With all this as a background, we can appreciate more than ever how living things must adapt themselves to life in the solar system. And we can understand why our world is probably the only planet to support life as we know it.

Key Words

centrifugal force	Mars	planet
elliptical	Mercury	radar
Evening Star	Morning Star	Saturn
galaxy	nebula	solar system
Galileo	Neptune	tide
gravitation	Newton	universe
Hale telescope	*orbit*	Venus
Jupiter		

Key Statements

1. The nine known major planets are, in order of distances from the sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

2. Planets change their positions with respect to the stars, but nevertheless follow true courses.

3. The rising, the moving across the sky from east to west, and the setting of the heavenly bodies are apparent movements. The apparent movement is due to the rotation of the earth from west to east.

4. Celestial bodies are held in their paths by a balancing of forces.

5. Great groups or families of stars are called galaxies.

6. Our sun is one of a billion or more suns which make up the Milky Way galaxy.

7. Our galaxy rotates once in about 200,000,000 years.

8. The Andromeda galaxy is similar to ours. It is about 800,000 light years away.

9. Great masses of glowing gas in space are called nebulae. There is a nebula in the constellation Orion.

10. The universe is thought to consist of millions of nebulae and galaxies in various states of development.

11. Ideas as to how the universe developed are expressed as theories.

12. The Law of Universal Gravitation states that every body in the universe attracts every other body in the universe.

13. The main cause of ocean tides is the force of attraction between the earth and the moon.

Thought Questions

1 How can you tell whether an object in the sky is a planet or a star?

2 What are some differences between a planet and a star?

3. Does the sun rise, move across the heavens, and set? Explain.

4 What do we mean by Evening Star and Morning Star? Why are Venus or Mercury usually the Evening Star or Morning Star?

5 Why does not the moon rise four minutes earlier each night as do the stars?

6 What is the difference between a nebula and a galaxy?

7 Arrange the following in order of size, beginning with the smallest galaxy, solar system, moon, sun, earth, universe, light year.

8 Explain why galaxies and nebulae remain in their relative positions

9 Why doesn't the earth drift away from the sun?

10 Is the high tide in any one locality always the same height? Explain your answer

11. Explain why the moon is more important than the sun in causing tides

12 How far have astronomers explored space?

Projects for Your Science Discovery Book

1 Make diagrams to illustrate the positions of the earth and the moon during high and low tides There is a time of year when high tides are higher than at other times. How is it explained?

2 Make a list of the names of men and women who have contributed largely to our theories of the development of the universe.

3 Write a story of Copernicus and how his theory differed from that of earlier philosophers.

4 Construct a telescope and try to discover the moons of Jupiter.

5. If you ever listen to a broadcast telling about "space ships" or other means of travel to other planets, try to separate the facts from the fiction

6 Show how the work of Galileo and that of Newton were endeavors to find the truth.

7 Look up and read American Indian legends relating to the sun and planets

8 Investigate, through library references, theories concerning life on Mars

9 Collect pictures of galaxies and nebulae Name each one Tell how far away each is, and its approximate size.

10. If you live near the ocean, keep a record of the times of the high tides for a month.

11. List some ways in which tides are useful. List also ways in which tides may be dangerous.

12. Try your hand at taking star trail pictures. Most interesting ones will be made by pointing the camera to the north and keeping the shutter open for three hours or more.

Florida State Advertising Commission

Sunset in Florida—Of all our states Florida extends the farthest south. These palm trees give us an idea of its semi-tropical climate. Do you know how the revolution of our earth around the sun gives Florida its warm, sunny climate?

TOPIC VIII

Daylight, Darkness, and Seasons

DO YOU KNOW—

1. Why day and night are equal only twice a year?
2. What causes summer and winter?
3. Why there is long twilight in the arctic?
4. Why there is no winter near the equator except on high mountains?

GENERAL PROBLEM 1

What Causes the Lengths of Day and Night to Change?

REVOLUTION AND ROTATION.—"Revolution" and "rotation"—do these words mean endless journeys to you? Our "air space ship" is the earth that hurries us along around the sun at the rate of about sixty-six thousand miles every hour. That speed is beyond our understanding. Moreover our "air space ship" itself is turning round and round on its axis once in twenty-four hours. This adds almost another 1000 miles an hour to our speed. Thus there are two motions—round and round the axis of the earth called *rotation,* and round and round the sun called *revolution.*

Our earth is not alone in its journey around the sun. There are known to be at least eight other planets revolving about the sun in the same direction as the earth. Mercury and Venus have orbits or paths inside that of the earth. Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto travel in orbits out beyond the earth.

The revolution of all the planets about the sun is from *west to east*. Imagine yourself looking down upon our great solar system from the North Star. You would see the sun at the center. The planets would be revolving about the sun in nearly circular paths in a direction opposite to that of the hands of the clock.

As you watched the earth from the North Star, you would see the earth also turning *counter-clockwise*, that is, from west to east Mars, Saturn, and Jupiter rotate in the same direction as the earth Uranus rotates in the opposite direction. The rotations of the other planets are not yet positively known.

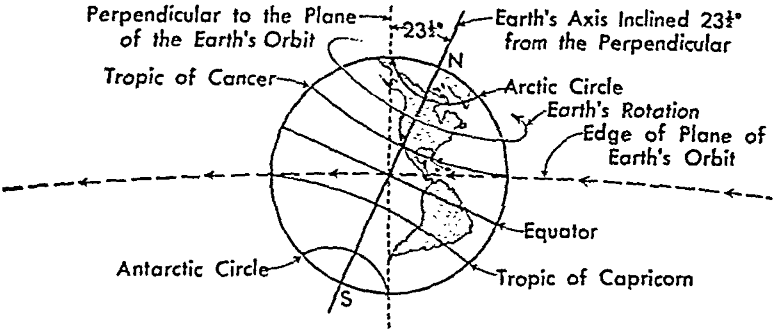
THE EARTH'S AXIS.—A wagon wheel turns about the axle. The axle (axis) of the earth is imaginary. However, the earth turns just as though it had a real axis You may think of the earth as a spinning top. But it will be different from a real top. If a top is set spinning on a table, its axis will be straight up and down, that is, perpendicular to the table. The top also may spin in just one place on the table. The earth on the other hand spins with its axis at a slant. As it spins, the earth moves in a great, nearly circular path. The earth, therefore, has two motions—rotation and revolution.

A flat surface like your desk top is called a *plane*. The flat surface marked off by the path or orbit of the earth is the plane of the earth's orbit.

The imaginary axis of the earth is tipped at an angle of 23 5° away from the perpendicular. It is tipped so that it forms a straight line pointing to the North Star. To illustrate the slant of the axis to the plane of the orbit, first hold a pencil straight up and down on your desk top. This position is called perpendicular. Now hold the pencil at an angle to the table. It will then be inclined. Study the diagram on page 205.

THE EFFECT OF ROTATION.—As you ride round and round on the earth you are in the light of the sun for a few hours. Then you are away from the sun for the rest of the twenty-four hours it takes for the earth to spin around once on its axis. Everybody knows that darkness follows daylight.

If you live in the northern part of the United States, you know that it gets dark earlier in the fall and winter. If you live in the south you know this too, but the change is not so noticeable as in the north. How all of us long for spring and the return of the long hours of daylight and the warmer sun!

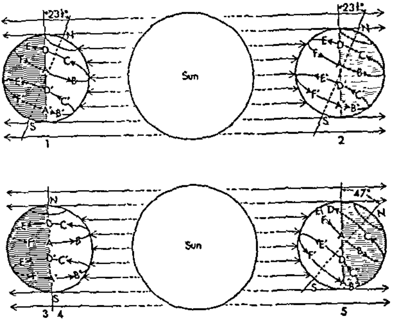


The Earth and Its Orbit.—If the earth's axis were straight up and down, it would take the position represented by the vertical dotted line. What are the effects of the inclination of the earth's axis? What two motions of the earth are shown here?

We know that the cause of the change from daylight to darkness is the turning of the earth on its axis—rotation. But do you know why some days are long and some are short? Let us try to find the answer. It has to do with the slanting of the earth's axis.

Long and Short Days and Nights.—What would happen if the axis of the earth were perpendicular to the plane of the earth's orbit? The length of day and of night would be equal all over the earth at all times of the year. This is shown in Drawing 3–4 on page 206. But the earth's axis is inclined 23.5° from the perpendicular. This results in a shortening or lengthening of day and night at different seasons, except at the equator. Let's see why this is so.

We must remember that the earth's axis is tipped. It is tipped so that the north end is always pointing toward the North Star. Thus for six months, the north end of the axis is inclined toward the sun. For the other six months the north



Changing Length of Day.—Diagram 1 represents the earth in its summer position, 2, the winter position, 3 and 4, spring and fall. Diagram 5 represents what would happen if the earth's axis were tipped at 47 degrees instead of 23½ degrees. In which diagram (1, 2, 3, or 4) are days longest in the northern hemisphere? What season is this? Which diagram shows shortest days north of the equator? What season is this? Where on the earth are days and nights always of equal length?

end of the axis is tipped away from the sun. We must also remember that half of the earth is always being lighted by the sun This is daylight While one half is having daylight, the other half is in shadow or darkness. This is night.

When the north end of the axis is inclined *toward the sun*, the days in the northern hemisphere are longer than the nights. This is shown in Drawing 1 above. You can tell this is so if you will trace the part of the circle $A–F$ that is in the light and compare this with the part in darkness.

In Drawing 2, the sun is again shining on the earth. Half of it is lighted The other half is in darkness or shadow. Now the north end of the axis is tipped away from the sun. This drawing represents the position of the earth when it is winter in the northern hemisphere. Imagine that the circle *A–B–C–D–E–F* is the path you would take if you journeyed around with the earth on a 24-hour trip. If you start at *A* and journey with the earth to *B* and *C*, you will be traveling in darkness. When the earth brings you to the point *D*, you will come into the sunlight and it will be day. While you are being carried on to *E* and *F* and back to *A*, you will be riding in daylight. Now measure your route and see how much more of it was in darkness than daylight.

On the same drawing trace a ride represented by a circle in the southern hemisphere. Will the daylight part of the ride be longer than the night? On the equator you would spend just 12 hours in daylight and 12 hours in night.

When the axis points neither toward nor away from the sun, the days and nights are of equal length all over the earth. This is shown in Diagram 3–4. Riding on the circle again, you would be in daylight from *A*, through *B* and *C*, to *D*. You would be in darkness through *E* and *F* back to *A*. If you measure this route, you will find that the two parts of the trip are of equal length.

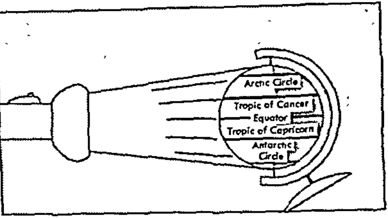
Our earth is in this position twice each year, once in the spring and again in the fall. These are the times of equal day and night all over the earth. They are called the *equinoxes.* Of course, at the equator the days and nights are always of equal length.

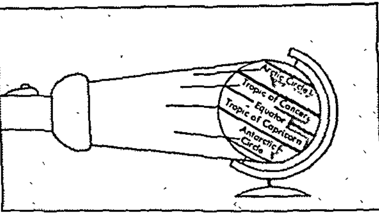
The difference in the lengths of day and night increases as one travels from the equator toward either pole. For this reason when it is winter in the northern hemisphere (Diagram 2) the *north pole* of the earth has night for six months. The *south pole* has day for those same six months. When it is summer in the northern hemisphere (Diagram 1) the north pole has a six month's day. The six month's night at the north or south pole is not six months of absolute darkness. The twilight and the moon give some light to the polar regions except for about three weeks.

Wherever you live, north or south of the equator, once a year you have the "longest day" and "shortest night." About

EXPERIMENT 17

What causes unequal lengths of day and night?





What form of energy is made use of in this experiment? What is its source? In this experiment again, the sizes of objects do not give an accurate representation of the real things Even so, the flashlight and globe will help you illustrate the causes of unequal lengths of day and night through the seasons

In the diagram the rays of light are shown spreading This is because of the limitation of drawing Actually the rays from the sun striking the earth are practically parallel

WHAT TO USE.—A six- or eight-inch slate globe on an axis; a flashlight; and a darkened room.

WHAT TO DO.—1. Draw a circle on the globe to represent the equator. Draw parallel circles north and south of the equator to represent the Arctic and Antarctic circles and the tropics of Cancer and Capricorn.

2. Hold the globe in front of the class with the axis in a vertical position. Holding the flashlight in the center of the room, turn the light toward the globe. Rotate the globe slowly. Observe how much of each circle is in the light and how much in darkness during one complete turn. Do all places on the earth under this condition have equal day and night?

3. Hold the globe at the side of the room to the right of the class with the axis inclined about 23.5° from the perpendicular and away from the class. Turn the beam of light on the globe. Rotate the globe as before. Observe the amount of each circle that is in daylight and in darkness during a complete turn. Notice if the equator circle is equally divided by light and darkness.

WHAT HAPPENS.—1. How many degrees from the equator should each of these circles be drawn to truly represent those on a map?

2. What proportion of each circle was lighted? (Half, more than half, or less than half.) Were one or more of the circles equally divided by light and darkness? Which ones?

3. What part of each circle was lighted? (Half, more than half, or less than half.) Was any circle equally divided by light and darkness? Which one?

CONCLUSION.—What are the causes of unequal day and night?

APPLICATION.—Would the differences between day and night be greater or less if the axis were inclined more than 23.5° from the perpendicular?

six months later you have the shortest day and longest night. How many hours long these will be depends upon how far north or south of the equator you live.

In the northern hemisphere, the longest day is about June 21. This is the day when the earth's axis is slanted most toward the sun. The shortest day is about December 21, when the axis is slanted most away from the sun.

Twilight is caused by the scattering (diffusing) of the sun's rays by dust and moisture in the air. After the sun sets, some diffused light finds its way out over the part of the earth turning

Ewing Galloway

Midnight Sun.—These pictures, taken a few minutes apart, show the movements of the sun during the long day at the north pole. Note that the sun remains almost level with the horizon. It was broad daylight when the pictures were taken. The darkness was caused by a lens filter that has to be used in taking pictures of the sun.

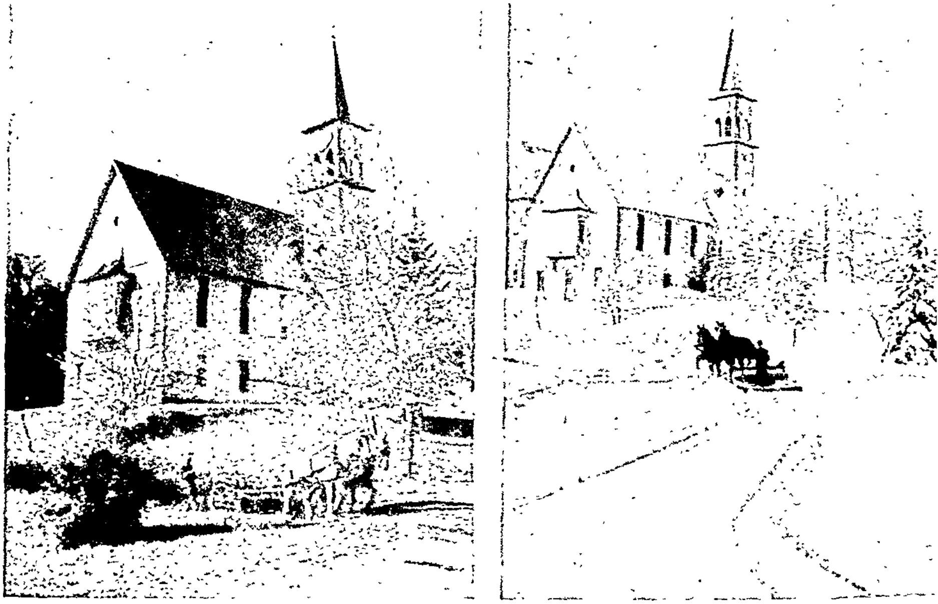
from the sun. At the equator twilight is very short, while at the poles it is nearly six months long. (Do you think there can be a twilight on the moon? Why?)

Perhaps you can understand why the lengths of day and night vary by studying the drawings on page 206. However, *Experiment 17 will help you to prove the cause of unequal day and night.*

GENERAL PROBLEM 2

What Causes the Changing Seasons?

MANY FACTORS.—Why is it warmer in summer than in winter? Why do the seasons follow each other in regular order? These are *not simple questions to answer*. *The change of the seasons is due to many causes, all related and all working together.* The revolution of the earth about the sun is one cause. The inclination of the earth's axis is another. The rotation of the earth plays a part. And the transfer of heat from one body to another must also be considered. To understand the change of seasons we must understand all these factors.

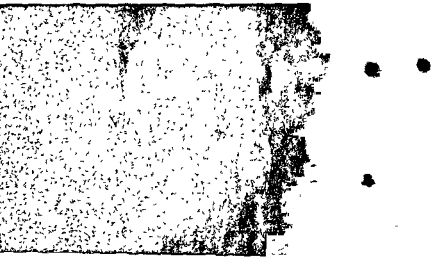


H. Armstrong Roberts

From June to January.—Most men and animals cannot follow the sun. They must adapt themselves to changing seasons. What are some of the ways in which men and animals adapt themselves to yearly changes in weather?

Heating Rays from the Sun.—When energy leaves a hot body, it goes out in all directions in straight lines like light rays. The energy is said to be *radiated* (page 157). You know that if you are facing a fireplace, the energy radiating from it strikes you in front but does not warm your back. If you would warm your back, you must turn it towards the fire. In the same way, only that part of the earth which faces the sun is able to absorb its rays of energy, and be warmed by them. When some energy rays are absorbed by a substance, heat is formed. So we may speak of the energy rays which are thus absorbed as heating rays. Remember that only energy rays which are absorbed by the earth can heat it.

Heating rays actually go out in all directions from the sun. But we are interested only in the parallel heating rays which strike the earth. The sun is so far away that all the rays that reach us are practically parallel, that is, going in the same direction.



Ewing Galloway

Midnight Sun.—These pictures, taken a few minutes apart, show the movements of the sun during the *long day at the north pole.* Note that the sun remains almost level with the horizon. It was broad daylight when the pictures were taken The darkness was caused by a lens filter that has to be used in *taking pictures of the sun.*

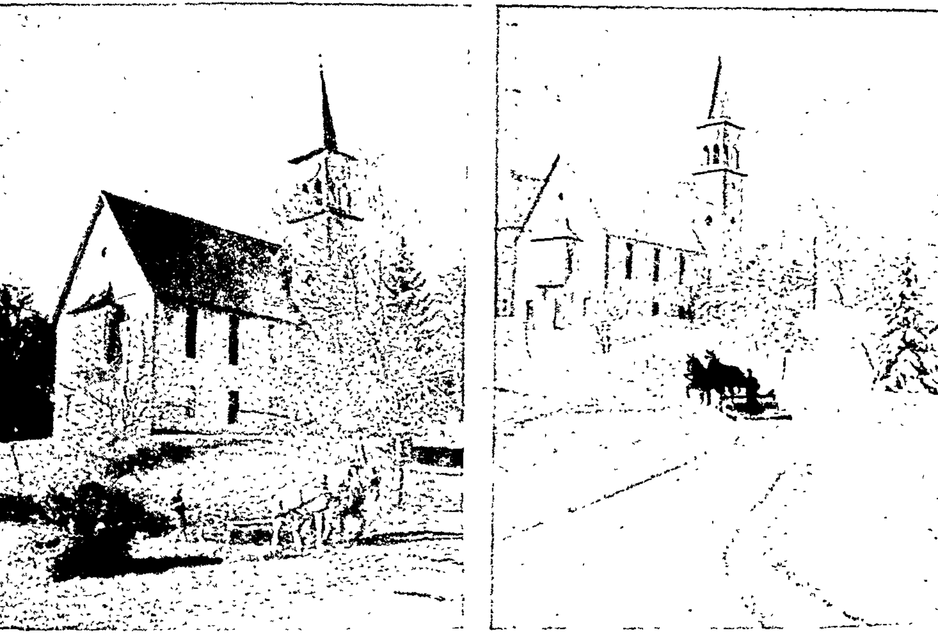
from the sun. At the equator twilight is very short, while at the poles it is nearly *six months long* (*Do you think there can be a* twilight on the moon? Why?)

Perhaps you can understand why the lengths of day and night vary by studying the drawings on page 206. However, Experiment 17 will help you to prove the cause of unequal day and night.

GENERAL PROBLEM 2

What Causes the Changing Seasons?

MANY FACTORS.—Why is it warmer in *summer than in* winter? Why do the seasons follow each other in regular order? These are not simple questions to answer. The change of the seasons is due to many *causes, all* related and all working together The revolution of the earth about the sun is one cause. The inclination of the earth's axis is another. The rotation of *the earth* plays a part And the transfer of heat from one body to another must also be considered. To understand the change of seasons we must understand all these *factors.*

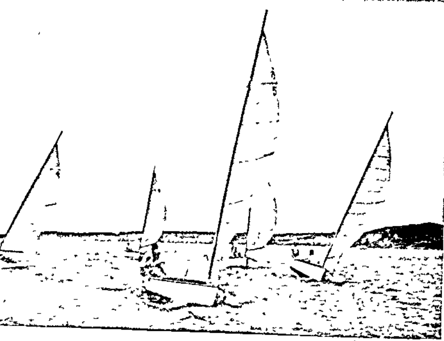


H. Armstrong Roberts

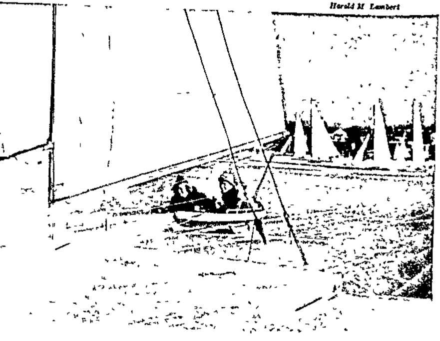
From June to January.—Most men and animals cannot follow the sun. They must adapt themselves to changing seasons. What are some of the ways in which men and animals adapt themselves to yearly changes in weather?

HEATING RAYS FROM THE SUN.—When energy leaves a hot body, it goes out in all directions in straight lines like light rays. The energy is said to be *radiated* (page 157). You know that if you are facing a fireplace, the energy radiating from it strikes you in front but does not warm your back. If you would warm your back, you must turn it towards the fire. In the same way, only that part of the earth which faces the sun is able to absorb its rays of energy, and be warmed by them. When some energy rays are absorbed by a substance, heat is formed. So we may speak of the energy rays which are thus absorbed as heating rays. Remember that only energy rays which are absorbed by the earth can heat it.

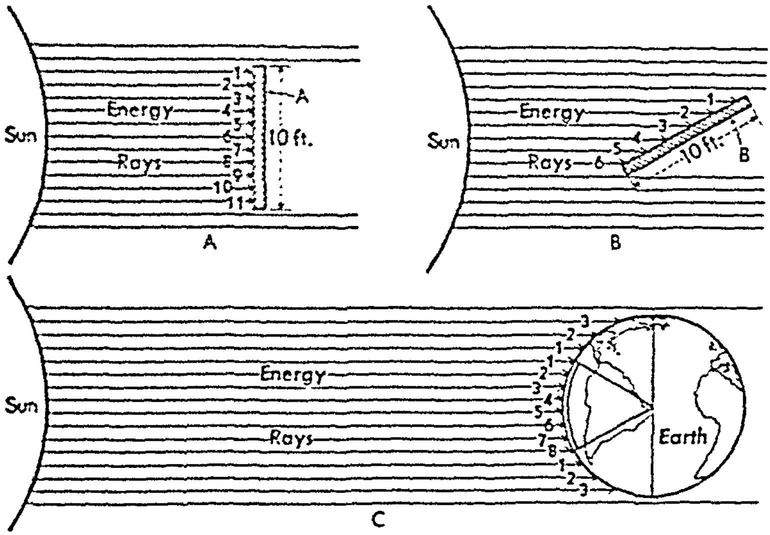
Heating rays actually go out in all directions from the sun. But we are interested only in the parallel heating rays which strike the earth. The sun is so far away that all the rays that reach us are practically parallel, that is, going in the same direction.


Kelsey Studio

Sailing All Year Round.—Man adapts his sports as well as his more serious activities to the changing seasons.

Harold M. Lambert


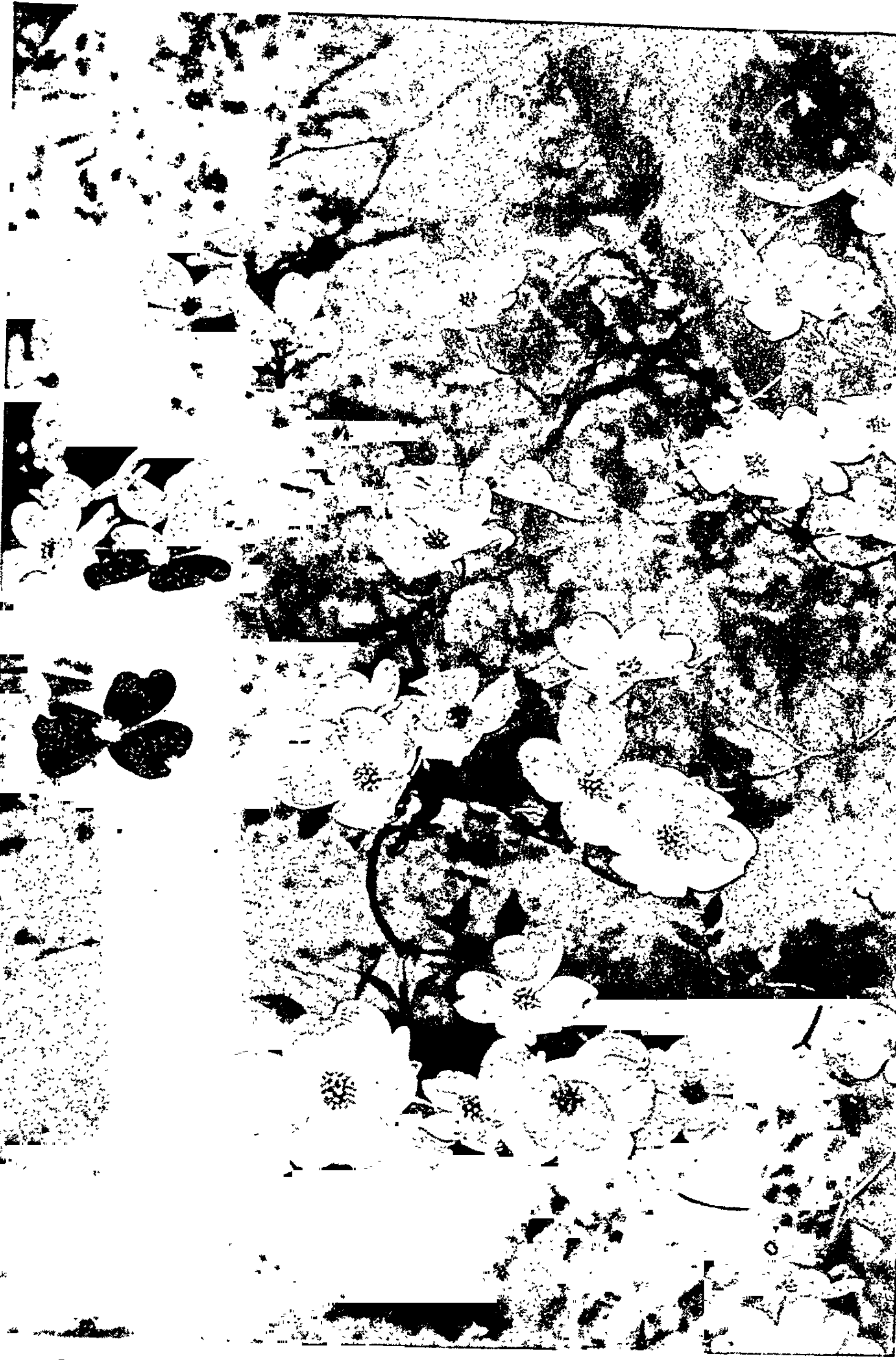
If you hold your hand broadside to a hot body, more heating rays will strike it than if you hold it edgewise. You will feel more heat. To picture this condition we can use lines as shown in the diagrams below. When block *A* is upright, eleven of the parallel heating rays strike it. When the block is tipped as in *B*, only six rays strike it in spite of the fact that the block *is the same length. Only its position* has been changed. In other words, the greatest number of heating rays will strike an object when it is held broadside or perpendicular to the rays.



Why Direct Rays Are Hotter than Slanting Rays.—How many heating rays strike the block A? block B? After studying these diagrams can you explain why slanting rays are not so warm as direct rays?

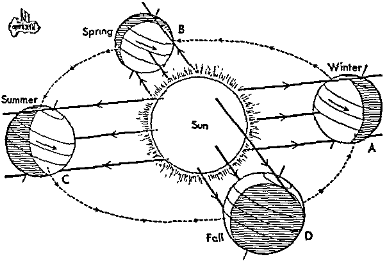
In part *C* of the diagram, equal lengths of the earth's surface are marked off. Notice that the middle length of the surface receives eight rays. The lengths above and below receive only three rays each. Of course these numbers *do not refer to actual* heating rays. They just show differences in the number of rays *striking different parts of the earth.* The diagram tells us that the part of the earth most nearly perpendicular to the rays receives more rays than any other part. In other words, *direct* rays furnish more heat than *slanting* rays.

Winter.—The constant procession of the seasons, even though unchanging, is always fascinating, and each season has its own particular beauty



Spring.—The variety and loveliness of spring and summer foliage probably help to make these seasons favorites with many people. This is a dogwood branch in blossom.

What causes the changes of seasons?



Why do you think this experiment is called a "Key" Experiment? Is it because it is important for each of us to understand what causes the changes in season?

In this experiment we shall use light energy to make things visible, but it is really heat energy that has to do with changes in seasons. Keep this fact in mind Also, you will remember that sizes and distances are not as they really are in the solar system Therefore, we shall be able to illustrate only the principles involved One principle to keep in mind is that energy rays heat a surface more if they strike it at right angles than if at a slant Another fact to keep in mind is that the axis of the earth always points in the same direction—toward the North Star.

We understand that the change of seasons is due to changes in the amount of heat the earth receives from the sun Our problem is to demonstrate why the amount of heat changes from time to time

WHAT TO USE —A small mounted globe and a frame of three parallel wires to represent heating rays, an object to represent the sun

WHAT TO DO —1 Set the globe so that the axis is perpendicular to the wires representing heating rays, and so that rays (wires) reach each pole, but with the axis inclined 23 5° away from the vertical toward the north as in *D* Slowly turn the globe one complete turn

2 Set the globe so that the axis is inclined 23 5° away from the

vertical and so that the north end of the axis leans *away from* the top heating ray as in *A*. Rotate the globe as before.

3. Keeping the axis pointed in this same general direction, move the globe counter-clockwise in a circular (really elliptical) path to position *B*. The axis will be perpendicular to center ray and the other rays will reach both poles as in *D*. Rotate the earth.

4. Again move the globe counter-clockwise to position *C*, keeping the axis inclined 23.5° but leaning toward the top heating ray, and pointing in the same direction as before. Rotate the globe.

5. Continue the swing counter-clockwise to the original position *D*, where again the axis is perpendicular to the rays and rays reach each pole. Rotate the globe.

6. Repeat parts 1, 2, 3, 4, and 5, but with the axis not inclined.

Note.—Repeat each of the above again and again until you know exactly what happens in each case.

WHAT HAPPENS.—1. Where are the heating rays perpendicular to the earth's surface, as it rotates? Where are they slanting? How does the rotation of the globe affect the direction of the rays at any place on the earth?

2. Where now do the rays act perpendicularly to the surface? Where do they strike the earth on a slant? What part of the earth receives the most slanting rays? Does any part of the earth fail to receive any rays at all in this position? What part? How does the rotation of the globe affect the direction of the rays on any part of the surface? Compare with position *D*.

3. Compare with the result in *D*.

4. Compare your observations with those in *A*. Where now do the rays act perpendicularly to the surface? Where do they strike the earth on a slant? What part of the earth receives the most slanting rays? What part of the earth receives no heat? How does the rotation of the globe affect the direction of the rays on any part of the surface?

5. Compare conditions now with what happened in 1.

6. If the axis were always perpendicular to the rays, would the amount of heat received by any part of the earth ever change?

CONCLUSION.—How does the inclination of the earth's axis affect the amount of heat received by the northern and southern hemispheres?

How does the inclination affect the heat received at the equator?

How does the rotation of the earth affect the amount of heat received at any one location in its orbit?

How does the revolution of the earth affect the amount of heat received by the northern and southern hemispheres? At the equator? In different positions in the orbit?

What season is in the northern hemisphere represented by *A*?

What season is represented by B?
What season is represented by C?
What season is represented by D?

APPLICATION.—Why does the temperature fall at a given place on a clear day as the sun sets lower and lower?

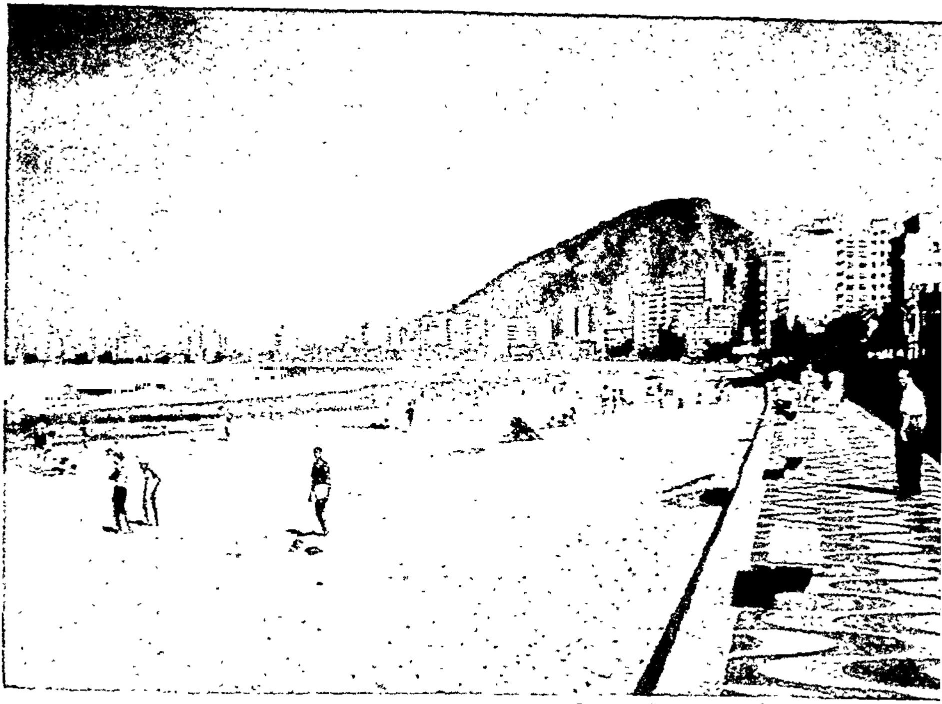
You know that the earth receives energy from the sun. You also know that changes in the amount of energy received by any part of the earth result in a change of temperature for that part And you know that the change in temperatures from season to season is gradual and slow. About six months is required for the change from summer to winter, and from winter to summer.

The different seasons, then, are caused by gradual changes in temperature of any one part of the earth. Another important fact about the seasons is that they follow one another in regular order The change of the seasons, therefore, must be due to *regular changes in the amount of heat* the earth receives from the sun. Our problem, then, is to determine what causes these changes in the amount of heat received by the earth under different conditions We should discover also why the seasons always come in the same order.

Experiment 18 will help you to understand what causes the changes in temperatures.

WINTER IN THE NORTHERN HEMISPHERE.—When the north end of the earth's axis is inclined 23.5° away from the sun, only slanting rays or no rays reach the northern hemisphere. This is also the time of short days and long nights in the northern hemisphere. Thus slanting rays, acting for only a few hours of daylight each 24 hours, cause winter in the northern hemisphere.

SUMMER IN THE NORTHERN HEMISPHERE.—Six months later, the north end of the earth's axis is inclined 23.5° toward the sun. Now more direct rays reach the northern hemisphere. Days are longer than nights. *More direct rays reaching the earth during long periods of daylight bring summer to the northern hemisphere.*



Courtesy Moore McCormack Lines

Copacabana Beach, Rio de Janeiro.—Rio de Janeiro, *as you probably know, is located south of the equator. How does the revolution of the earth affect the climate in Rio de Janeiro?*

Opposite Season in the Southern Hemisphere.—When the northern hemisphere is slanted away from the sun, the southern hemisphere is slanted *toward* the sun. Thus when it is winter for the United States, it is summer for lands in the southern hemisphere. When the north end of the earth's axis slants toward the sun, it is summer in the northern hemisphere and winter in the southern. Between the two extreme positions, the earth moves to positions resulting in spring and fall. The seasons follow one another gradually and with unfailing regularity.

Effect of the Earth's Distance from the Sun.—When asked the cause of summer, some people who have not studied science say it is because the earth is nearer the sun. As a matter of fact that is not true. When it is summer in the northern hemisphere, the earth is actually about 3,000,000 miles farther from the sun than it is in winter. You now understand that

What season is represented by B?
What season is represented by C?
What season is represented by D?

Application.—Why does the temperature fall at a given place on a clear day as the sun sets lower and lower?

You know that the earth receives energy from the sun. You also know that changes in the amount of energy received by any part of the earth result in a change of temperature for that part. And you know that the change in temperatures from season to season is gradual and slow. About six months is required for the change from summer to winter, and from winter to summer.

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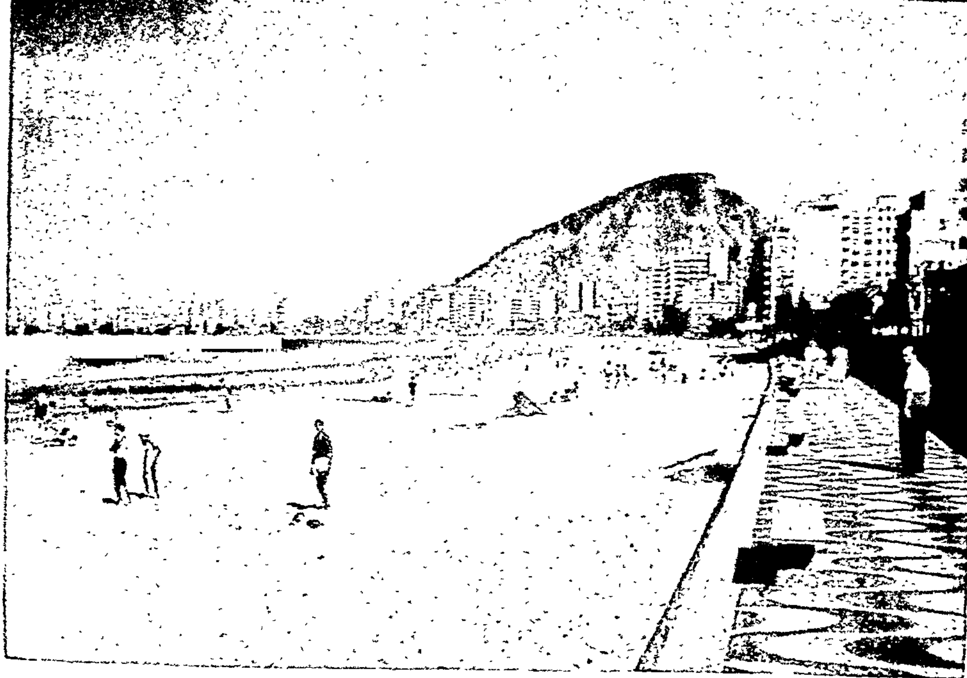

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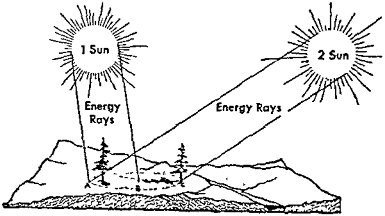
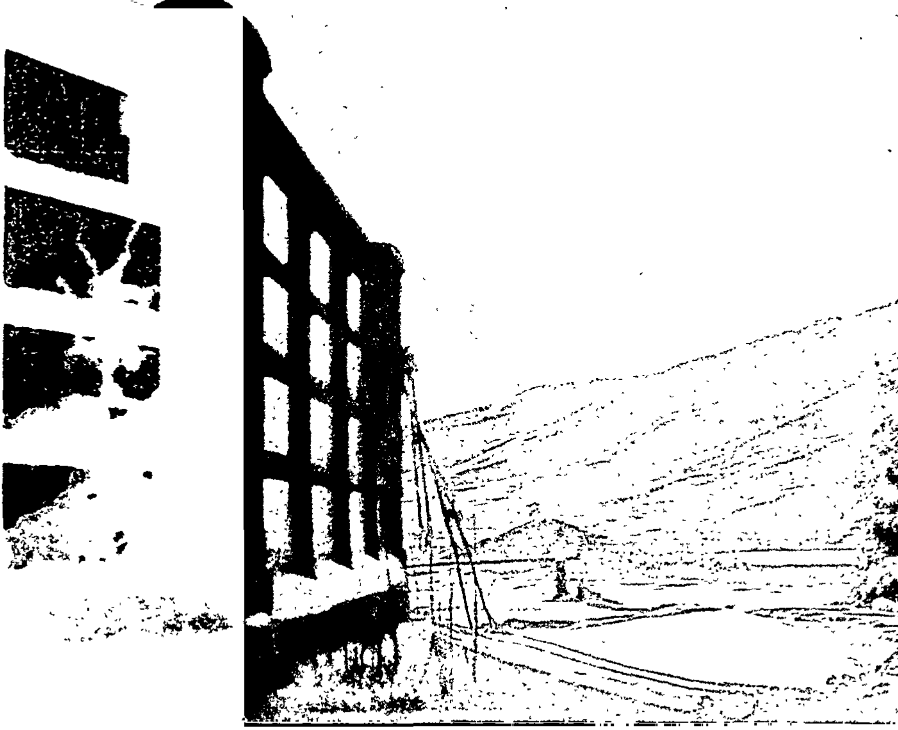
When the rays are slanting and the days are short, the earth is not heated as much as when the rays are more direct and the days are longer. These conditions result because of the inclination of the axis, the revolution about the sun, and the rotation of the earth.



How the Sun's Position Affects the Amount of Heat the Earth Receives.—When the sun is nearly overhead (Sun 1), its rays heat the land from A to B. When the sun is nearer the horizon, the same amount of heat is spread over a much larger area—from A to C. Which season does Sun 1 represent? What time of day does Sun 1 represent? Sun 2?

THE EQUINOXES.—We know that the axis of the earth always points in the same direction. It follows that as the earth travels around the sun it reaches a position where the north end of the axis slants away from the sun. This position accounts for the cold of the winter season in the northern hemisphere. (*A* in diagram, page 216). When in the opposite position with respect to the sun, the northern hemisphere receives its greatest heat. This produces the summer season. (*C* in diagram, page 216).

Now as the earth swings from the first to the latter position, it moves to a place where the north end of the axis slants neither away from nor toward the sun. (*B* in diagram, page



Sun Valley, Idaho.—The climate at Sun Valley makes it one of our nation's most popular vacation spots. Strong winter sunshine and snow attract skaters and skiers from all over the United States. Note the skis in this picture leaning against the swimming pool.

216.) In this midway position, both ends of the axis are the same distance from the sun. Both ends of the axis receive the same amount of heat. It is our spring season. On the first day of spring we should expect equal day and night all over the earth. Actually the earth's atmosphere bends the sun's rays, so that day and night are not exactly equal at this time. The date (about March 21) when the earth is in this position is called the *spring (or vernal) equinox.* It is the "first day of spring."

We know that the earth swings from its summer position (northern hemisphere) back to the winter position. Half way along, it reaches a place where again the axis is tipped neither toward nor away from the sun. (*D* in diagram, page 216.)

The time when this occurs (about September 21) is called the *autumnal equinox* This is the "first day of autumn." Because of the bending of the rays of light, day is actually about twenty minutes longer than night. Otherwise day and night would be of equal length

FIELD RESEARCH

Make a study of the adaptations living things make to the changing seasons Describe the changes in some plant—a garden flower, wild flower tree or shrub

Select an animal for a similar study. A beaver, bear, squirrel, rabbit, or deer would be a good one to study. Have several of these reported in class

List several ways in which you adapt your way of living to the changing seasons

THINKING THINGS OVER.—*Day and night, summer* and winter—these are the things we have been studying in this topic Perhaps the most remarkable thing about these changes is their regularity.

Can you explain now why night follows day with such regular order? Can you tell why days are longer than nights at certain times of the year? Can you explain why the noonday sun is higher in the sky during the summer months than in winter?

We have learned that our summer season is the time when our part of the earth receives its greatest amount of heat. We tried an experiment to show that the inclination of the earth's axis is important in bringing about a change of season. And, of course, we saw that the rotation and revolution of the earth are factors causing the regularly changing seasons and day and night

We know now that all these things work together. Length of day and night, and the change of seasons are related to each other.

Can you explain the relationship between the length of day and night and the seasons? Such an explanation will be a good review of this topic.

Key Words

axis	hemisphere	season
circle	orbit	spring
degree	perpendicular	torrid zone
ellipse	polar regions	tropics
equinox	revolution	twilight
heating rays	rotation	vernal

Key Statements

1. The earth revolves about the sun from west to east.

2. The earth rotates on its axis from west to east.

3. The orbit of the earth about the sun is elliptical.

4. The axis of the earth is inclined 23.5° away from the vertical. It always points in the same direction (toward the North Star).

5. Day and night are caused by the rotation of the earth. Their lengths vary on account of the inclination of the earth's axis and its revolution about the sun.

6. The change of seasons is a result of varying amounts of heat received by the earth's surface.

7. Variations in the amount of heat received by the earth's surface from the sun are caused by the revolution about the sun of the earth with its axis inclined at 23.5°.

8. Rays of energy from the sun are parallel. They heat more strongly when they act directly (perpendicularly) than when they act at an angle.

9. The motions of the earth are regular, hence the heat received by the earth varies in an orderly manner. This in turn results in an orderly sequence of the seasons.

10. Winter occurs in the northern hemisphere when the earth is in such a position that the north end of the axis is inclined away from the sun. At this time it is summer in the southern hemisphere. When the north end of the axis is inclined toward the sun, the seasons are reversed.

11. Spring and fall occur when the earth is in such a position that both the north and south poles are at the same distance from the sun and receive the same amount of heat.

12. About March 21 and September 21 the days and nights are of equal length. These dates are called the *vernal* and the *autumnal equinox*.

13. Plants and animals, including man, adapt their habits to the changing seasons.

Thought Questions

1 The earth is farthest from the sun when it is summer in the northern hemisphere Why, then, is it summer?

2 Why must the inclination of the earth's axis be considered when explaining the cause of unequal days and nights?

3 How would the apparent motion of the sun, moon, and stars be affected if the earth turned from east to west on its axis?

4 What would be the effect on the variations in the length of day and of night if the axis of the earth inclined 47° away from the vertical? How would the seasons be affected?

5 What evidence can you give from personal observations that plants and animals anticipate the change of seasons?

6 The axis of Venus is nearly vertical. What effect would this have on the seasons of Venus as compared with the seasons on the earth?

7 Which part of the earth's surface always receives the most direct rays?

Projects for Your Science Discovery Book

1 Draw a diagram to represent the sun and earth and use arrows to show the direction of the two motions of the earth.

2 Make a study of the migration of birds, finding out how far and how fast they fly, where they go, and why. Do any birds live the year round in the same environment, adapting their habits to the changing seasons?

3 Make a study of the shelters used by man in the tropics, in the temperate zone, and above the Arctic circle. Compare them as to building materials, construction, and warmth.

4 Make a study of the diet of man in each of the three zones mentioned above

5 Locate and record the points on the horizon of your locality where the sun rises and sets on the longest day of the year. Repeat on the shortest day, and on the two days having day and night of equal length. Represent the horizon by a circle and mark the locations and date them Stationary objects (to be labeled), such as trees, corners of buildings, fence posts, telegraph poles, and chimneys, may be used to mark the location on the horizon where the sun rises and sets Two such objects should be discovered that are in a straight line with the positions of rising and setting

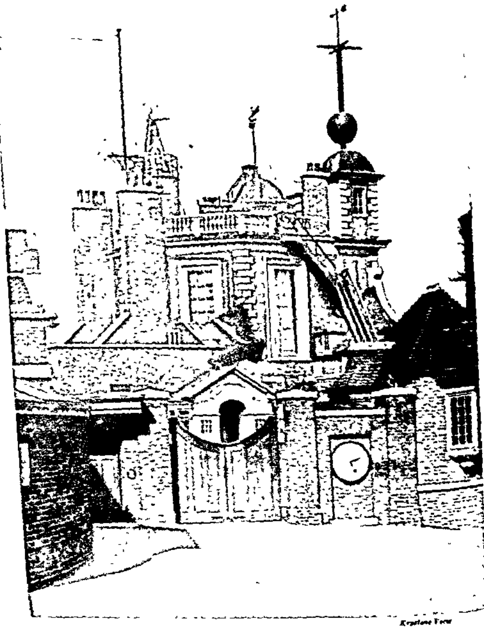
6 Darken the room, and with your flashlight and an old tennis

ball, with a knitting needle stuck through it to represent the earth on its axis, demonstrate how rotation causes day and night.

7. Do you regulate and conduct the affairs of your life as dependably as nature does hers? Describe some things in nature that are good examples for you to follow.

8. Using graph paper, plot the time of the rising and setting of the sun for a month. Start with the longest or shortest day of the year or one of the two days when day and night are equal. You may wish to make the record for a whole year. An almanac will give you the time of rising and setting of the sun.

9. Using graph paper, plot the time of the rising and setting of the moon for a month.



Keystone View

The Right Time.—This is the original Greenwich Observatory. The clock on the right is numbered from 1 to 24. Recently the staff and equipment were moved to the country, where clearer air makes better observations possible. But the location is still on the prime meridian.

TOPIC IX

Earth Measurements

DO YOU KNOW—

1. How many degrees there are in a circle?
2. The names of two imaginary circles north of the equator?
3. How a ship at sea reports its position?
4. How time is related to place?
5. Why the sun rises in New York before it does in Chicago?
6. Why time zones were established?

GENERAL PROBLEM 1

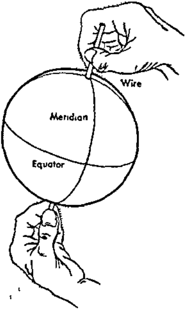
How Are Places Located on the Earth?

Describing Position.—How do we tell where a place is on the earth? Usually we describe the position of the place in relation to some other place. For example, your home may be so many miles from town, on a certain road. Or it may be six houses from a certain corner. Your school may be at the corner of two streets. Even a town or a city is described as being so many miles from another city, and in a certain direction.

But how can we describe a location far out in the ocean where there are no landmarks? How can a position be described high in the sky, hidden by clouds from the earth?

There is a way of describing the exact location of any place on the earth. To do this, the earth has been marked off with great imaginary circles. Some of these circles run around the earth intersecting at the north and south poles. At right angles to these is another group of circles. One of these circles is the

The "Avenues" and "Streets" of the Western Hemisphere—What are the real names of these imaginary lines?



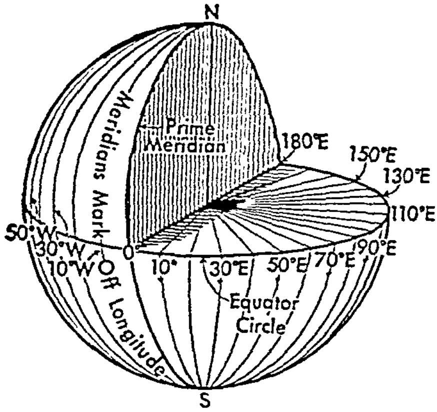
Model—Make a model, as described in the Field Research, to help you understand "meridian" and "equator."

equator. North and south of the equator, and parallel to it, are other imaginary smaller circles.

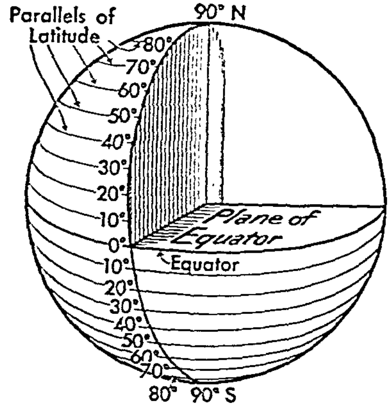
MERIDIANS AND PARALLELS.—The great imaginary circles which intersect at the poles run north and south. They may be thought of as the avenues of the earth. These are the *meridians*.

The equator circle runs east and west around the middle of the earth at right angles to the meridians. It may be thought of as the "Main Street"—East and West. Smaller circles parallel to the equator are called *parallels*. They may be thought of as the numbered streets, 1 to 90 to the north and south. Street 90 to the north would be the North Pole. The *parallels* get smaller and smaller toward the pole. Right at the pole the circle is merely a point which locates the end of the earth's axis.

Thus every part of the earth is laid out with imaginary streets running east and west (the parallels) and imaginary avenues running north and south (the meridians). The part of the earth north of the equator is called the northern hemisphere. The part south of the equator is called the southern hemisphere.



Meridians.—Here you see the "avenues" of the world. Notice that these "avenues" run north and south on the earth's surface and that they all meet at the North and South Poles.



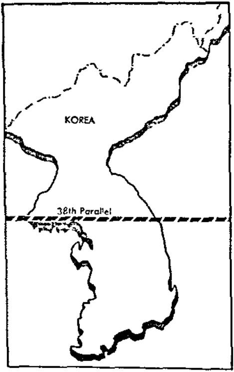
Parallels.—The "streets" of the world run east and west. Which "street" is the longest? Can you think of any reason why these imaginary lines are called *parallels*?

FIELD RESEARCH

Let a tennis ball with a wire passing through the center represent the earth and its axis. With a pencil draw several great circles intersecting where the wire comes out of the ball. These circles will represent *meridians.*

Draw one great circle halfway between the ends of the axis. It will represent the earth's *equator.*

The meridians mark off the distances around the equator and parallels, as is shown in the diagram. Since a circle for convenience is divided into 360 degrees, let us say that the meridians divide the equator and parallels each into 360 equal lengths called *degrees.* Also, the parallels may be spaced so as to divide each meridian circle into degrees. Since parallels north and south start with the equator circle, they are marked off in degrees north and south of the equator. Between the equator and the pole is one quarter of a great circle. Thus there are 90 degrees between the equator and the pole. Therefore the meridians are marked into 90 spaces (degrees) both north and south of the equator. See the diagram above.



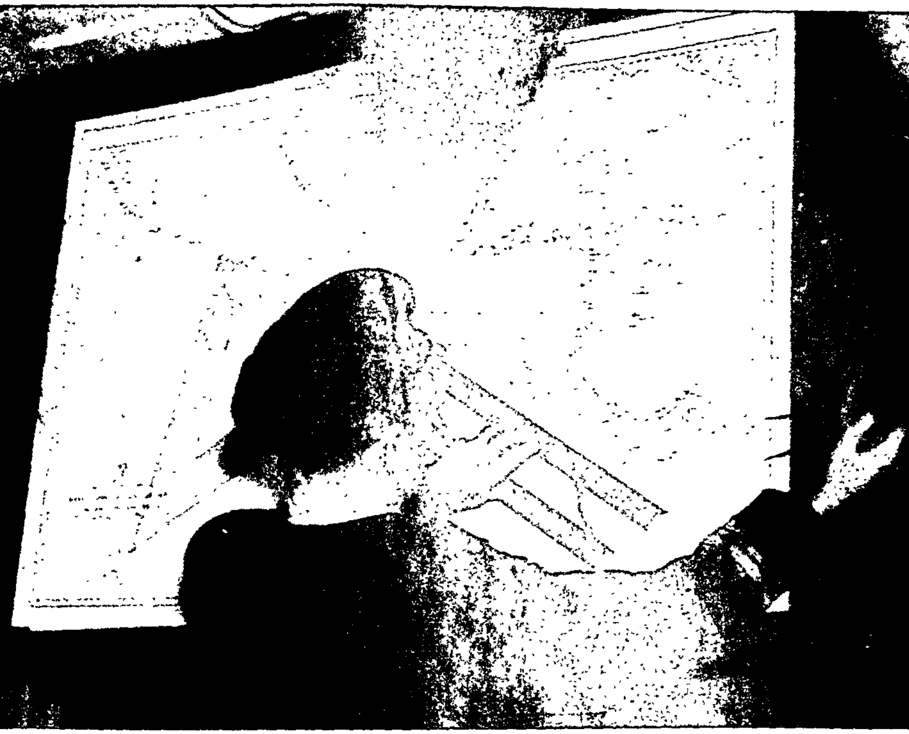
The 38th Parallel in Korea.—Sometimes the imaginary lines around the earth become real enough to fight over.

THE PRIME MERIDIAN AT GREENWICH.—Our own modern town which has a Main Street may also have a Main Avenue. The equator circle, as you know, is our Main Street of the earth. The meridian which passes through Greenwich (grin/ij), England, is our Main Avenue. It is called the *prime meridian.*

Greenwich is a borough of London, England. Long ago a great observatory was built there. By 1884, the business of the world had grown so huge that the need for a standard or *prime (first) meridian* was very great. A group of representatives from twenty-six nations met at Washington, D.C., to decide the question. The majority agreed to name the meridian which passes through Greenwich, the *prime meridian.*

Any other meridian would serve just as well as this one for a starting point. But to avoid confusion, it is necessary to have *one* prime meridian. All east or west earth measurements are, therefore, based on reference to the Greenwich prime meridian. This arrangement has worked out very well.

RECORDING LOCATIONS.—The degrees east and west from a prime meridian are called degrees of *longitude.* The degrees north or south of the equator are called degrees of *latitude.* The meridians are numbered east and west from Greenwich, that is, from 0° to 180° each way. The parallels are numbered north and south from the equator, that is, from 0° to 90° each way. For the purposes of greater accuracy, each degree is subdivided into 60 equal parts called *minutes.* For still more accurate

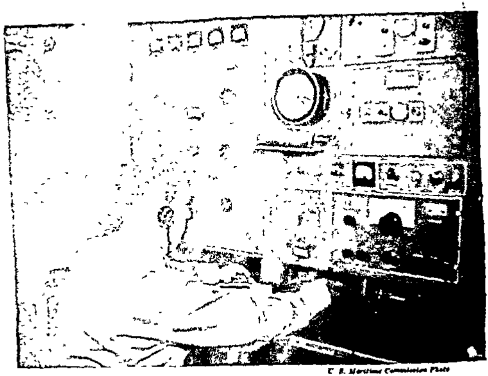


Plotting His Position.—This officer in the chart room of a commercial ship is figuring the position of his vessel. Along with maps, he uses parallel rules and a compass for his calculations. The role of the navigator is vitally important to the completion of a voyage by ship or plane.

work each minute may be divided into 60 equal parts called *seconds*.

Therefore, to locate any spot on the earth, all you need to say is that it is so many degrees (minutes, etc.) east or west longitude, and so many degrees (minutes, etc.) north or south latitude. This marks the spot where the meridian and the parallel cross each other.

The half of the earth that lies between the prime meridian and 180° west longitude is the western hemisphere. That part between the prime meridian and 180° east longitude is the eastern hemisphere. Of course 180° west longitude and 180° east longitude are the same meridian. It is just halfway around the earth from the prime meridian at Greenwich, England.



U. S. Maritime Commission Photo

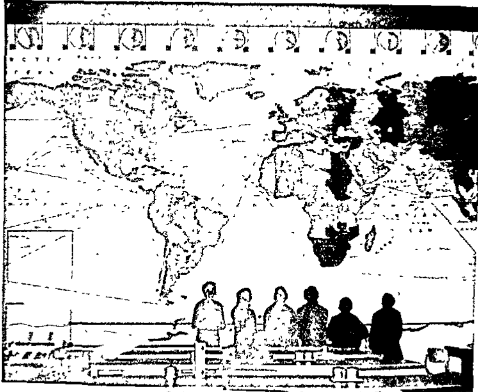
A Radio Shack.—This ship's radio operator is sending the position of his ship in latitude and longitude. In time of danger, rescue operations are directed to a ship in distress by radio reports of its latitude and longitude

This network of imaginary lines around the earth is not useful only to ship and plane navigators, of course. It is vitally important to surveyors in planning boundaries, to engineers in outlining great building projects, and to many others who must deal with exact locations on the earth.

MAP STUDY

Study a large map of the United States or the world. Notice the fine lines that run up and down and across the map Which are meridians? Which are parallels?

The lines running up and down are marked in *degrees of longitude.* Those drawn across the map are marked in *degrees of latitude.* Locate your own town or city on the map Determine its position in terms of latitude and longitude All places in the United States will be *west* longitude and *north* latitude. Explain why.



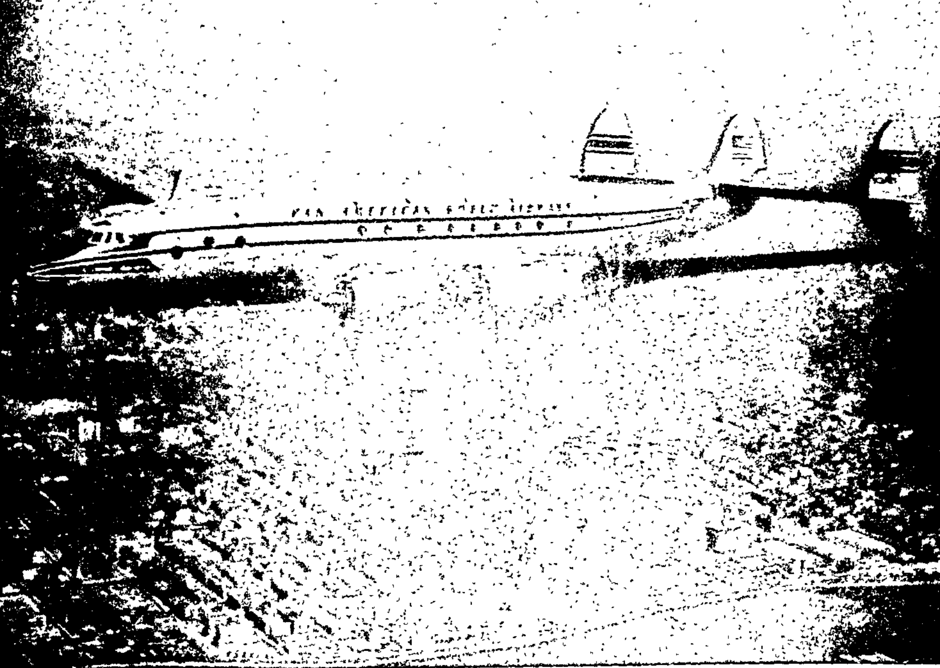
Courtesy *The Evening Bulletin—The Sunday Bulletin,"* Philadelphia, Pa.

World Time Zone Map.—This map shows the time zones all over the world. Above every other zone is a 24-hour clock which gives the exact hour at all times. It is 12 midnight in the Pacific Time Zone and 8 a.m. in England.

divided by 15 equals 5). When it is four o'clock in Philadelphia, it is nine o'clock in London.

If the earth were flat, like a table, and the sun rose above the east end, everyone would see the sun rise at the same instant. That this is not so is one proof that the earth is spherical and turns on its axis.

STANDARD TIME.—Actual sun time is different for every degree of longitude. That is, the actual time of sunrise and the time of sunset are different for every place east or west of your house. This is because the earth is constantly turning from west to east. A little thought will show that it would be very hard to conduct the world's business if all our clocks were run on sun time.

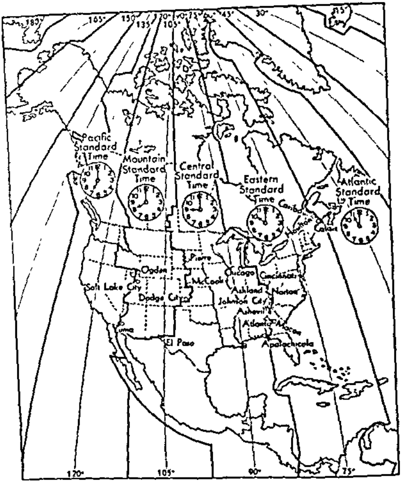

Courtesy Pan American World Airways System

Beating Time.—Modern air travel makes it possible to cross several time zones in one day. In a cross-country flight from New York to California, how many time zones would a plane cross?

There was a time, though, when each locality had its own time. It is said that there were 27 different times in the state of Illinois. Wisconsin may have had as many as 38.

By 1883, the situation had become so confusing that something had to be done about it. As the railroads pushed farther and farther west, their time schedules became hopelessly snarled. Thus the railroads met in 1883 and agreed on a system of time zones. The system was so successful that everyone began to follow it. Not until 1918 were the *standard time zones* made part of the law of the land. These zones are: Atlantic Standard Time, Eastern Standard Time, Central Standard Time, Mountain Standard Time, and Pacific Standard Time zones.

TIME ZONES.—A strip of the United States, running north and south for a certain distance on either side of the Philadelphia meridian, uses the sun time of the Philadelphia me-



North American Time Zones.—Pick out the meridian passing through the approximate center of each time zone. Account for the irregular boundary lines between the zones. How many hours' difference in time is there between New York and San Francisco? Which zone do you live in?

ridian. That is to say, all clocks in that strip are set to agree with the clocks in Philadelphia. The time for this section is known as Eastern Standard Time.

A second strip, lying directly west of this section, is marked off as a Central Standard Time zone. In this zone the time is one hour earlier than in the Eastern zone. When it is 7 o'clock in the Eastern zone, it will be 6 o'clock in the Central zone.

The third zone includes the mountain region of the west, where the time is called Mountain Standard Time. West of the third zone lies the fourth zone, and here the time is called Pacific Standard Time.

All of the United States lies in the four time zones. Parts of Canada east of Maine are in another time zone—the Atlantic Standard Time zone. The imaginary line separating Eastern from Atlantic Standard Time runs along the eastern boundary of Maine. This is shown on the map on the opposite page.

By this scheme of time zones any place in a given zone may keep its clocks on standard time and yet not be more than one half hour ahead or behind sun time.

FIELD RESEARCH

Obtain timetables of the principal transcontinental railroads and a map of the United States. From the timetables determine the boundary cities of the time zones. Mark these places on your map. Connect the boundary cities by lines, and you will have approximately mapped the time zones.

Check the accuracy of your zone boundaries by the time zone map on page 236.

If the time zones were exactly placed, they would have meridians 15° apart as boundary lines. But for business and transportation reasons changes had to be made. For example, cities which have much commerce with each other should be in the same time zone.

A general standard time has been adopted for all continents. The prime meridian of Greenwich, England, is the meridian from which the standard time of the world is determined. This is called *Greenwich mean time* and is abbreviated G.M.T. World-wide radio program managers make use of G.M.T. in arranging for world broadcasts. How many hours difference is there between G.M.T. and E.S.T. (Eastern Standard Time)?

DAYLIGHT SAVING TIME.—Daylight saving time (D.S.T.) is not a time zone. Neither is it a standard time. Any zone

How Can Navigators Find Their Way?

How the Navigator Keeps His Course.—Navigators of ships and planes are often out of sight of land for long periods of time. How can they find out where they are and the direction they are going?

The navigator uses special compasses to determine his directions However, direction alone does not tell position. For this reason the navigator must know his exact latitude and longitude at given times in order to be sure that he is holding to his course Knowing his location, the navigator can, with the aid of the sun, the stars, and compasses, continue on his course. He can determine his latitude from the stars on cloudless nights or from the sun on cloudless days.

You remember the earth is laid out in imaginary streets and avenues like a town. The stars and the sun are really marks in the sky, and the navigator has a map on which these sky marks are drawn.

The North Star, an Important Sky Mark.—Let us try to understand how the North Star aids the navigator.

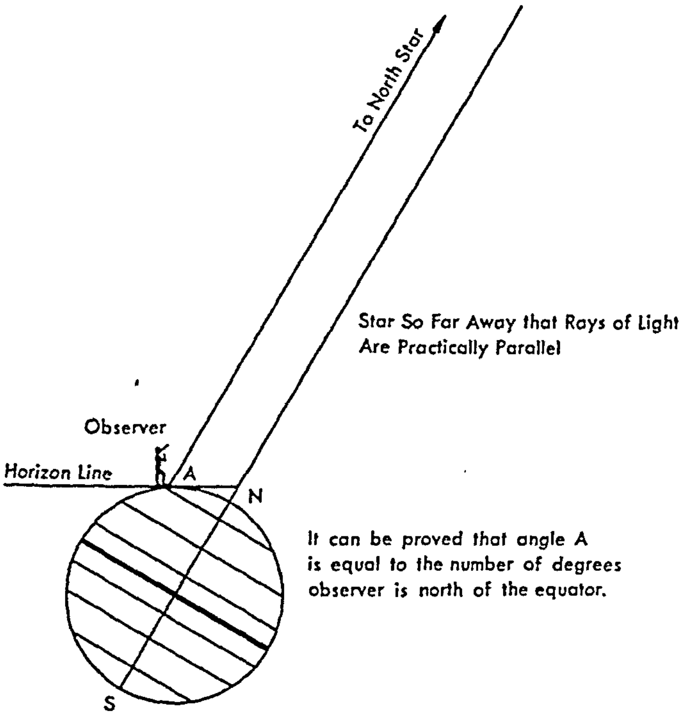
The angle formed by a line drawn from your eye to the North Star and the line of your horizon is the same for everybody on your same parallel of latitude. If you went north from your first position, the angle would get larger. If you went south, the angle would be smaller. The diagram on page 241 will show that this is so.

You can very easily determine your latitude by merely measuring the angle the North Star makes with the horizon lines.

Strictly speaking, you should stand at the center of the earth when looking at the North Star to determine its altitude. However, the star is so far away that it doesn't make any practical difference in your measurement.

Thus the latitude of any place in the northern hemisphere can be determined by measuring the angle of the North Star above the horizon.

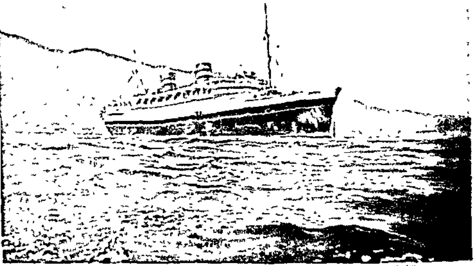
Experiment 19 is an interesting project for a clear evening when the moon is not bright. Read the experiment carefully so that everything will be ready when the clear night comes.



Finding Northern Latitude.—The angle formed by the horizon line and the line of sight to the North Star equals the latitude of the observer. In other words, one may find his north latitude by measuring the altitude of the North Star.

LATITUDE FROM THE SUN.—Have you ever noticed the shadow of a telephone pole at morning, noon, and night? If so, you know that the shadow is shortest at exactly noon by the sun. In other words noon sun time occurs when the sun is highest in the sky. This helps a navigator to determine exact noon wherever he is. Also, by measuring the angle of the sun above the horizon at exact noon, the navigator can calculate his latitude. The angle in degrees subtracted from 90° gives the approximate latitude.

Due to the inclination of the earth's axis and the revolution of the earth about the sun, the altitude of the sun at exact noon varies with the day of the year. Hence for accurate results by this method a correction is made by navigators.

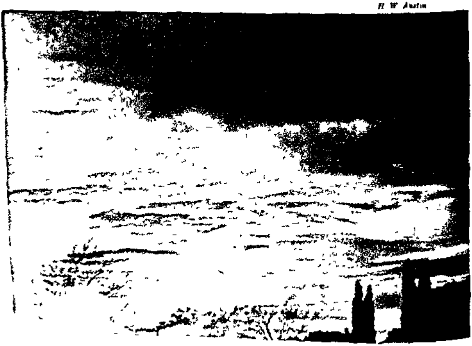


Blackthorn

Steering a Straight Course.—If a traveler knows the stars, he can always find his direction. Our vessels travel faster and farther than the ancients', but the same stars guide us on our journeys.

The End of Day.—Sunset in one country means sunrise somewhere else as our earth continues its endless journey through space.

H. W. Austin

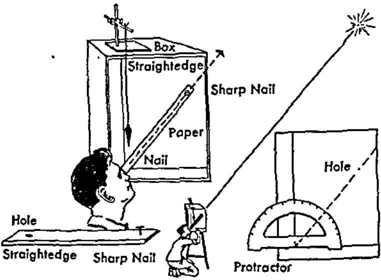


D. L. Burkett

Alaska's Long Day.—The Arctic Circle is an imaginary line dividing the Arctic region from the North Temperate Zone. Northern Russia, the Scandinavian Peninsula, Greenland, northern Canada, and Alaska are in the Arctic Circle. On one day every year, usually about June 22, the entire Arctic region has twenty-four hours of daylight. On another day, about December 22, this region has twenty-four hours of darkness.

EXPERIMENT 19

What is the latitude of your home?



To do this experiment you will need to make careful preparations in advance It will be a good project to make the apparatus in the school shop if you have one.

Here again you will make use of light energy. A principle involved is that light travels in straight lines Think that over. Suppose light did not travel in straight lines, how could you do the experiment?

WHAT TO USE.—A plumb line and support, a good-sized box to which is tacked a paper marked with a right angle whose sides are horizontal and vertical; a narrow straight-edged stick fastened to the box by a nail as shown above The stick will swing about the nail. Near the other end of the stick pass another sharp nail so that only the point sticks out When this nail is pressed slightly it will make a prick in the paper underneath; a high stool; a carpenter's square, a protractor; and a flashlight

WHAT TO DO —On a clear night place the stool where there is a good view of the North Star Set the box on the stool with the paper toward the east and pointing north Hang the plumb bob from the support so that it swings free Adjust the box so that the vertical side of the right angle on the paper will be exactly in line with the plumb line

Now with your eye in the position as shown in the diagram, sight toward the North Star. Adjust the stick so that the nail in the far end is exactly in line with the North Star The two nails act as sights. When they are in line with the North Star push on the upper nail to make it prick the paper underneath. Now take the paper into the light and draw a line through the two pricks so that it intersects the horizontal line.

Lay the protractor against the horizontal line as shown in the diagram. Then read the angle made by the star direction line and the horizontal line. This angle is the altitude of the North Star. It is equal to the latitude of the place where the observation is made. For the sake of greater accuracy you should try the experiment several times and take the average of the several angles for your result.

Conclusion.—What is your latitude? Is it north or south?

Application.—What is the length of the longest day and of the shortest day at your latitude? Use the apparatus to measure the "altitude" of some other star.

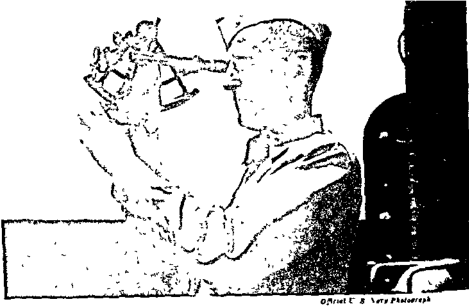
The navigator uses an instrument called a *sextant* to determine the altitude of the sun at exact noon. He looks through the sextant to read the angle the sun makes with the horizon at the instant the sun reaches its highest point. Making a correction for the time of the year, he reckons his true latitude.

Finding Longitude.—The navigator carries with him a special clock or watch called a *chronometer*. It is set so that it agrees exactly with a master clock at Greenwich Observatory. By means of radio the accuracy of the chronometer is checked regularly.

If the navigator wants to know his longitude, he determines when it is exact noon, or, if at night, he may determine the time from the stars. From the difference between the time shown by his chronometer, which is sun time at Greenwich, and the time by the sun or stars he can calculate his longitude. He knows that for each hour's difference in time he has changed his position 15°.

Thus the navigator determines his latitude from the sun or the North Star, or certain other stars. He determines his longitude by means of the difference in time. Then he can locate his position on a map which he always has with him.

Thinking Things Over.—Exact measurement is necessary in science if we are to know with real accuracy about many things. When you buy a pound of butter you expect it to be



Official U. S. Navy Photograph

Sighting His Sextant—This ship's navigator is "shooting the sun." His calculations will help determine the exact position of the ship.

weighed accurately This means that the scales used must be accurate, that the grocery man know how to use it properly, and that he read it correctly

So it is with scientists. They must have good measuring instruments, use them properly, and record the observations honestly. Of course, scientists must be able to understand their measurements and interpret them correctly.

Using instruments and numbers sometimes makes a problem more difficult to understand. But often it helps one to understand the problem better. Any problem is usually easier to solve if we are sure of the exact facts.

Your study of earth measurements should help you realize that measurements are of little value unless they are accurate. When the navigator observes the altitude of a star, his observations must be exact. A little error may mean part of a degree error in the latitude. And just part of a degree may mean several miles on the earth's surface. In the same way, a little error in determining longitude may put a ship or a plane far off its course There is no room for errors, however small, in the important work of the navigator.

FIELD RESEARCH

Try to determine the approximate latitude of your home by measuring the altitude of the sun at noon.

Use the same materials listed in Experiment 19 and a magnetic compass. Follow the same procedure as in Experiment 19. At exact noon the shadow of a plumb line on a horizontal surface (top of box leveled) will point north.

The compass should be laid on the box so that the shadow falling across it will tell you when it is approximate noon. At that instant you should mark the angle of the sun direction with the horizontal and vertical lines on your paper. Since the magnetic north and true north vary at different locations, the compass will give you only the approximate north and therefore only approximately noon.

The angle in degrees subtracted from ninety is approximately your latitude. Compare the determination with the results obtained by use of the North Star method.

KEY WORDS

chronometer
compass
diameter
equator
Greenwich
latitude
longitude
meridian
noon
parallel
prime meridian
sextant
standard time
telescope

KEY STATEMENTS

1. Places may be located on the earth by stating their latitude and longitude. Latitude is the distance in degrees north or south of the equator. Longitude is the distance in degrees east or west of a prime meridian.

2. Fifteen degrees of longitude is equal to one hour of time.

3. Standard time zones were established for convenience in comparing the times of different localities.

4. The north latitude of a place equals the angular altitude of the North Star above the horizon. The latitude of any place may also be determined from the altitude of the sun at exact noon. This angle, subtracted from 90°, must be corrected for the position of the earth in its orbit.

5. Longitude is determined by the difference in time between standard time at Greenwich, England, and the sun time at the place involved. One hour's difference equals 15° longitude.

6 The International Date Line lies approximately along the 180th meridian When crossing the line going east, one day is gained; when going west, one day is lost.

Thought Questions

1 Why is it helpful to be able to give the position of a place in terms of latitude and longitude? How else could one describe the location of a city? A ship at sea? An airplane in the air?

2 Why are 15 degrees of longitude equivalent to one hour of time?

3 Why is it necessary to have a prime meridian?

4 Why is the plan of standard time zones better than that of having every place go by sun time?

5 Referring to page 238, in which United States time zone was Bill when he heard Australia?

6 What is the altitude of the North Star at the north pole? At the equator?

7. How is the altitude of the North Star related to latitude?

8 How is Greenwich Mean Time used to determine longitude?

9 How is daylight saving time related to sun time? To standard time?

Projects for Your Science Discovery Book

1 From a map read the latitude and longitude of five places, based on the standard (Greenwich) prime meridian. Now on your map read the position of your home town in latitude and longitude, using the 75th meridian as your prime meridian Record your results

2 Make reports of news items that indicate the importance of the radio in navigation of the sea or air

3 Read in *Skyward*, page 191, what Commander Byrd says about the importance of chronometers and their accuracy in connection with his North Pole flight Make a report of your reading

4 Discuss the advantages and disadvantages of daylight saving time.

5 To determine the true north from the sun, set up a stake about four feet tall where the ground is level. Make sure the stake is exactly vertical When the shadow of the stake is shortest, the shadow is pointing due north

6. Having determined the true north by the shadow cast by the stake, compare with it the magnetic north direction as indicated by

a compass. About how many degrees from the true north is the magnetic north?

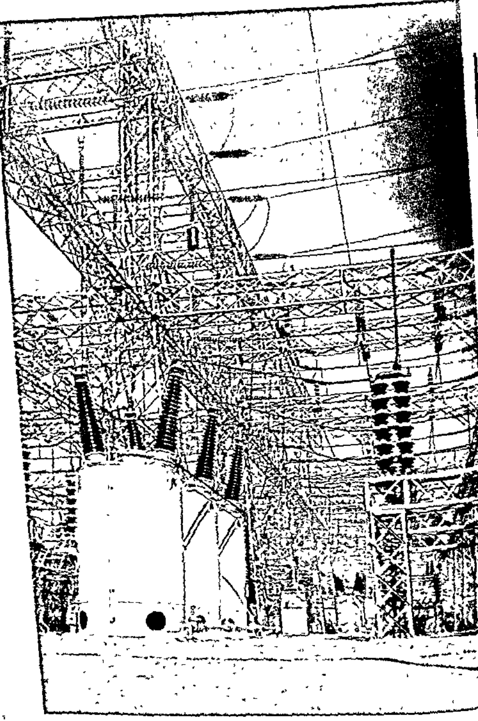
7. Learn to determine the north and south direction, using a watch and the shadow of a match or slender stick. Hold the watch in a horizontal position so that the hour hand points toward the sun; that is, so that it is in line with the shadow made by a match or slender stick held exactly vertical.

When the watch is in this position, the north and south direction is a line halfway between the hour hand and the figure twelve.

8. Make a sun dial in a sunny place on your lawn and learn to tell time by it.

9. If you would like to make a sun dial, a cross staff, a quadrant, or a real telescope, consult such books as *Starcraft* by Barton and Joseph, published by Whittlesey House, New York.

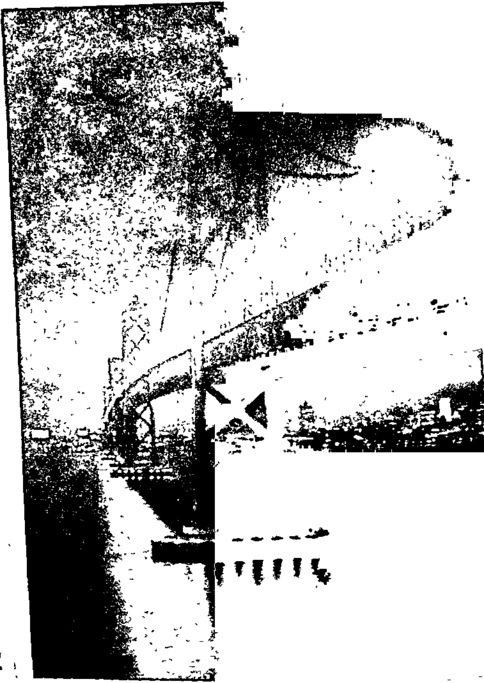
10. Read about the setting up of standard time zones in the United States. Accounts may be found in reference books or encyclopaedias. Report to the class.



Power.—Transformers are modern symbols of power—power from mighty waterfalls changed into electricity—power to give us light—power to give us heat—power to run manufacturing plants.

UNIT III

Magnets and Electricity



Courtesy Redwood Empire Association

Electric Diamonds.—San Francisco and the Bay region are fairyland after dark. Brilliant lights mark the famous Bay Bridge. High above on the bridge towers are airplane warning lights. Near the water are marking lights for boats. On the shore lights twinkle in San Francisco homes.

TOPIC X

Using Magnets

DO YOU KNOW—

1. Why one end of a compass needle points to the north?
2. How to make an electromagnet?
3. Which metals are attracted by magnets?
4. How an electric motor works?
5. How the electricity in your school is made?
6. How atomic energy may someday be used to make electricity?

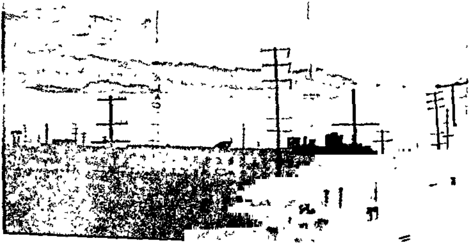
GENERAL PROBLEM 1

What Are Magnets?

Early Magnets.—Long, long ago it was discovered that certain stones would attract bits of iron. It was also known that these same stones could be used to point directions. If such a stone hung freely from a fine thread, it would turn so that the same end of the stone would always point in the same direction. These stones soon came to be known as *lodestones.*

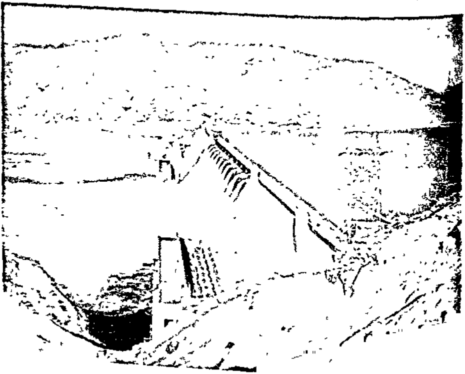
We know now that these lodestones were magnets. The lodestones were actually a kind of iron ore we now call magnetite. It was given this name because it has the properties of a magnet.

The lodestones of long ago were natural magnets. Nowadays we have artificial magnets. They may be in the shape of bars, or they may be bent in the shape of a horseshoe. No matter what the shape of the magnets, you know that they attract iron and steel.



When Darkness Falls—Street lights, house lights, neon signs, radio towers all remind us of the importance of electricity in our lives.

Grand Coulee.—Grand Coulee Dam, on the Columbia River, has a capacity of 2,420,000 horsepower. It is the world's largest hydroelectric power plant. The dam reservoir is 151 miles long.

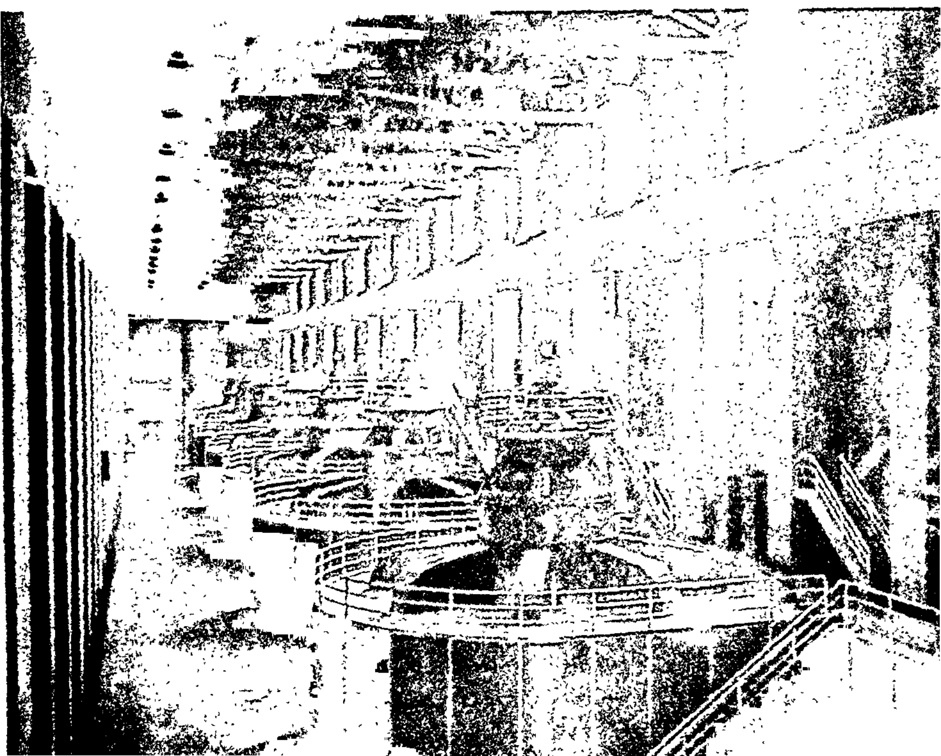


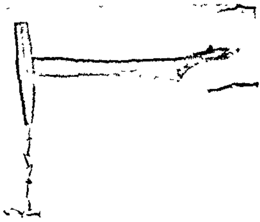
FIELD RESEARCH

Put a few paper clips, thumb tacks, bits of copper wire, small brass screws, steel brads, and pennies in a pile. Remove as many objects as possible using only a magnet. Keep a record of those picked up by the magnet. Which ones remain in the pile? Try using two or three magnets. Does the number of magnets make any difference?

Poles of a Magnet.—If a bar magnet is suspended so that it swings freely, it will come to rest in a north-south position. One end of the magnet will be pointing north. The other end will be pointing south. The end which points to the north is called the *north pole* of the magnet. It is usually marked N. The other end of the magnet is the *south pole*. It is marked S.

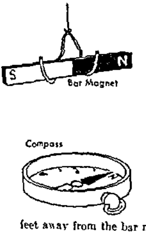
Making Electricity.—These generators are installed at the Hoover Dam in the Colorado River. Each generator is driven by a waterwheel below the floor. The waterwheels are turned by the force of the water.





Permanent Magnets.—The metal hammer head on the left has been magnetized artificially. How can this be done? The lodestone (iron ore magnetite) is a natural magnet. It occurs in nature with the magnetic properties you see demonstrated here.

FIELD RESEARCH



Suspend a bar magnet from a support as shown in the drawing. Use thread to hold the magnet. Let the magnet come to rest. Observe a compass several feet away from the magnet. The black end of the compass needle points north. Does one end of the bar magnet point in the same direction? Is there a mark on this end of the magnet? If there is no mark on the magnet, mark it N with chalk.

Move the magnet and its support to another part of the room. Does the N end of the magnet point in the same direction as before?

NOTE.—Keep the small compass several feet away from the bar magnet. Do not set up the bar magnet near a radiator or other steel objects.

ACTION OF MAGNETIC POLES.—One of the most important properties of magnets is their effect on each other. The north pole of one magnet always attracts the south pole of another. Thus we can say that *unlike poles of magnets attract each other.*

What happens when two like poles are brought together? An N pole will repel, or push away, another N pole. An S pole will repel another S pole. Thus *like poles of magnets repel each other.*

You may have observed this law of magnetism before, but you should try the experiment on page 258 because it is so important.

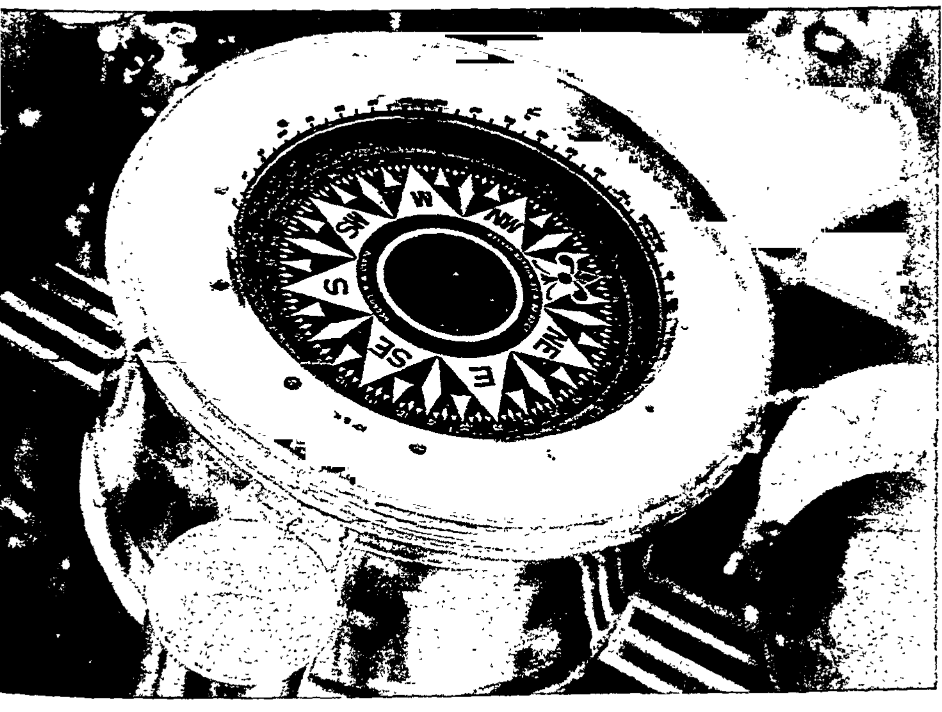
COMPASS.—A compass is a magnet. The most simple kind of a compass is a magnetized needle floating on water. You can make such a compass by following the directions in the next Field Research.

When you suspended a bar magnet and let it come to rest, you also made a compass.

Why does a compass "point north"? The action of a compass is based on the law of magnetism you have learned above. Actually the earth is a huge magnet. One of its poles is near the north end of the earth's axis. Its other pole is in the antarctic

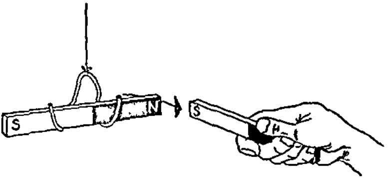
A Ship's Compass.—The large metal balls on either side of the compass "compensate" it. The metal in a ship becomes magnetized and will affect the compass. These balls are adjusted so that they counteract the ship's magnetic effect on the compass.

Robert E. Coates



EXPERIMENT 20

How do magnets affect each other?

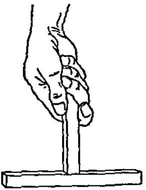


This experiment proves an important law of magnets The black end of the magnet is the north end. The white end is the south end.

WHAT TO USE.—Two bar magnets; a short length of wire to make a "cradle"; some strong thread, a wooden support.

WHAT TO DO.—1. Set one bar magnet in the cradle, attach the thread, and suspend the magnet as shown in the diagram.

2. Bring the S pole of the second magnet near the N pole of the swinging magnet Bring the S pole near the S pole of the suspended magnet. Observe what happens in each case



3. Place the N pole of the second magnet near the N pole and then the S pole of the swinging magnet Observe what happens in each case

WHAT HAPPENED.—Tell exactly what you observed when No. 2 and No. 3 above were tried.

CONCLUSION.—1. How do like poles of magnets affect each other?

2. How do unlike poles of magnets react to each other?

APPLICATION.—One bar in the accompanying drawing is a magnet. The other is not Which one is the magnet? How do you know?

regions. The magnetic north pole of the earth attracts an unlike pole of another magnet. Thus a compass needle or any free-swinging magnet will be affected by the earth's magnetism.

FIELD RESEARCH

Using one end of a bar magnet, stroke a needle several times in the same direction. Start at the eye of the needle and slide the end of the magnet along to the point. Lift the magnet away, and repeat the process.

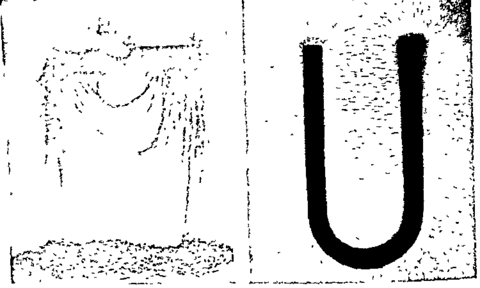
Gently place the needle on the surface of water in a glass or china dish (*not* metal). Observe whether the needle comes to rest in a certain position. Use another compass to determine which direction this is. Which end of your compass needle points toward the north?

A similar compass may be made by magnetizing a needle in the same way as above, and then placing it on a flat cork floating on water.

At this point some straight thinker may say, "But why does the *north* pole of a compass point toward the north pole of the earth? I thought like poles repelled each other." Like poles do repel each other, as you learned in Experiment 20. The confusion comes from the names we have given to the poles of compasses or magnets. Actually the north pole of a magnet is the *north-seeking* pole. Or you may think of it as the *north-pointing* pole. In common practice, we leave off the "seeking" or "pointing," and just call the pole "north." If we are to be absolutely correct, though, we should call the north pole the *north-seeking* pole.

Magnetic Lines of Force.—What is magnetism? No one really knows for sure. We can say that magnetism is an attraction certain substances have for each other. Mostly we know about magnetism by what it does; that is, how magnets act.

Scientists believe that every magnet is surrounded by a *magnetic field*. In some unknown way, a magnet gives out magnetic force in all directions. This magnetic force around the magnet is the magnetic field. The magnetic force is strongest at the poles of the magnet. It seems to come out of the magnet in the form of lines. Hence we can think of the force as *magnetic lines of force* around the magnet.



Magnetic Lines of Force—The iron filings show the position of the lines of force. Where is the magnetic effect strongest in each magnet? How do you know?

Magnetic lines of force are invisible. They are not matter; they are a force They cannot be seen, but we know they exist by what they do. You can prove for yourself that lines of force do exist by trying the experiment on page 262. Notice how the iron filings tell you that the lines of force are the strongest at the poles of the magnet. Notice also, when you are doing this experiment, how the filings show that the lines of force from two like poles repel each other.

Making Magnets.—Earlier in this general problem we learned that magnetite is a natural magnet. Because magnets are so useful, it is fortunate for us that they can be made. Only three natural substances can be magnetized; that is, can be made into magnets. These are iron, nickel, and cobalt. Iron is by far the best metal for making magnets. Recently, however, a combination of all three of these metals has produced strong and long-lasting magnets. Such powerful magnets are being used instead of latches on some of our modern refrigerator doors.

A piece of steel may be magnetized by stroking it in the

Courtesy General Electric

Magic Magnets.—There is no latch on the door of this refrigerator. Very powerful tiny magnets pull the door shut and hold it closed. Do you think this arrangement for closing the refrigerator door automatically is a good one? Why?

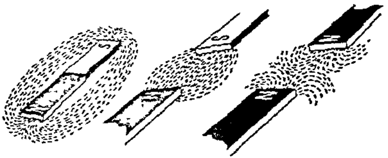
same direction with one pole of a magnet. You did this in making a needle compass. Scientists are not certain why this action magnetizes the iron, but they do have an *explanation.* It is possible that each molecule in the steel is itself a tiny magnet. If an N pole is rubbed along the steel in the same direction, it will *attract the S poles of the molecules.* This will point the S poles of the molecules all in the same direction. Thus the entire piece of steel becomes a magnet. This is a good example of scientific reasoning.

You can spoil a magnet by heating it or striking it with sharp blows. This probably breaks up the orderly pattern of the molecules. *Magnets will also lose their magnetic force if they* are stored with like poles next to each other. Again, scientists reason that the magnetic forces repelling each other probably cause the molecules in the magnets to be pushed out of proper arrangement.

There is still another way in which magnets may be made. This is by the use of electricity. Electricity and magnetism are the subject of our next general problem. Our study of electricity and magnetism will help us understand the working of many useful machines, from electric motors to doorbells.

EXPERIMENT 21

Are there magnetic lines of force around a magnet?



The dotted lines in this diagram are the artist's way of showing lines of force. Of course no one can see magnetic lines of force, although you will prove that they exist. It will help if you remember that lines of force are just that—*force* not *matter*. Black represents the north pole; white represents the south pole.

WHAT TO USE.—Two bar magnets, a pane of glass about twice as long as one of the magnets, three pieces of cardboard, iron filings.

WHAT TO DO.—1. Place the pane of glass over one of the magnets. Sprinkle iron filings on the glass. Tap the glass gently to help the filings become arranged. Observe the arrangement of the filings.

2. Remove the filings from the glass. Place two magnets under the glass. Have the magnets in a straight line with the N pole of one about 1 to 2 inches from the S pole of the other. Again sprinkle iron filings on the glass. Observe the arrangement of the filings.

3. Set up the apparatus this time so that two N poles are about two inches apart under the glass. Sprinkle filings on the glass, and note their arrangement.

4. Repeat *1*, *2*, and *3* above using a piece of cardboard instead of the glass. *In each case, draw with pencil the lines formed by the iron filings.* Be sure to label the poles of the magnets in these three drawings.

WHAT HAPPENED.—1. Where did most filings seem to collect? Where did the fewest filings seem to collect? What was the general arrangement of the filings on the glass?

2. What was the general arrangement of the filings when two unlike poles were under the glass?

3. What was the arrangement of the filings when two like poles were under the glass?

4. Make labeled drawings to show the arrangement of the filings as drawn on the cardboards.

CONCLUSIONS.—1. Does magnetic force act through glass? How do you know?

2. Can magnetic lines of force be seen? How did you prove that there are lines of force around a magnet?

APPLICATION.—Which part of a magnet should be used for its greatest magnetic force?

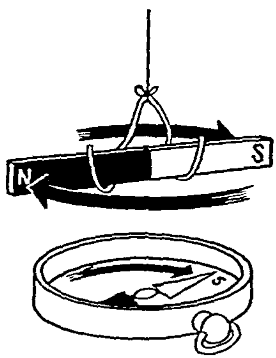
GENERAL PROBLEM 2

How Are Magnetism and Electricity Related?

MAGNETISM FROM AN ELECTRIC CURRENT.—You have learned two ways to tell whether an object is magnetized. If *an object has magnetism in it, it will affect another magnet.* For example, a bar magnet swinging over a compass will affect the compass. This, we remember, is because like poles repel, and unlike poles attract.

FIELD RESEARCH

Suspend a free-swinging bar magnet over a compass. Mount the magnet so that it is just far enough from the compass to affect it. If the magnet is brought too close to the compass the latter will be spoiled. Spin the magnet slowly. Notice how the compass also spins.

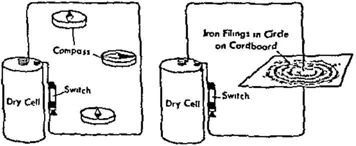


We have also learned that we can use *iron filings to show the* presence of a magnetic field The filings collect along the lines of force coming from the magnet. Thus we can use either of these *methods as a "test" for magnetism.*

If an electric current is passed through a wire, a magnetic field will be formed around the wire. A compass brought near a plain piece of copper wire will not be affected. This is because copper is a non-magnetic material. As soon as an electric current flows through the wire, a magnetic field is set up. You can prove this by trying the accompanying Field Research.

FIELD RESEARCH

Bring a compass near a length of insulated copper wire. Observe the direction of the N end of the compass. Take the wire away. Observe whether the compass needle changes any. Next connect the wire *to a dry cell and switch as shown in the drawing. With a compass nearby*, close the switch Observe any movement in the compass needle. Repeat at several places along the wire Notice the effect on the compass needle when the switch is closed and when it is open; that is, when electricity is flowing through the wire, and when no electricity is flowing.

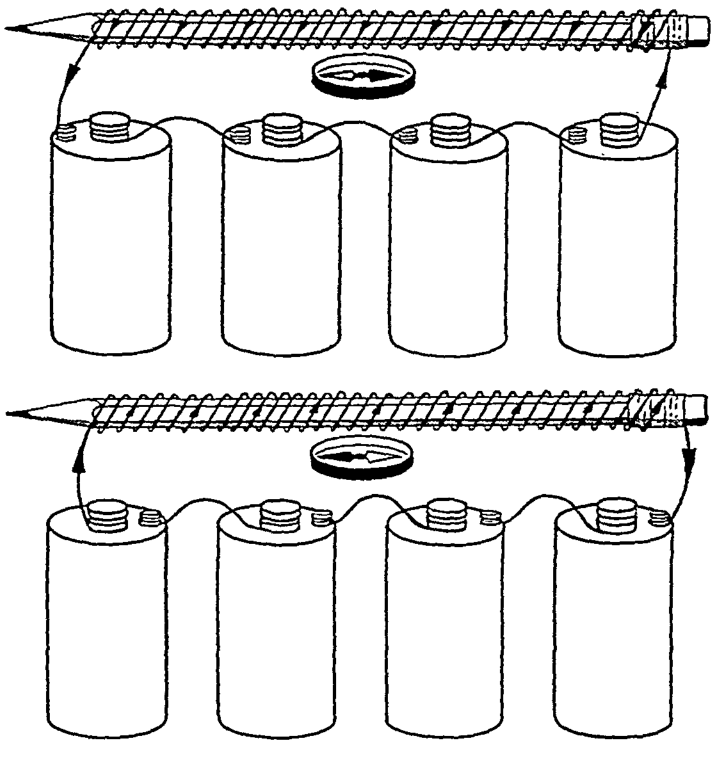


Caution: Do not leave the switch closed too long at any one time. Why not?

The same effect may be shown by running the wire through a hole in the center of a piece of cardboard. Sprinkle iron filings on the cardboard, and then close the switch Observe what happens to the filings

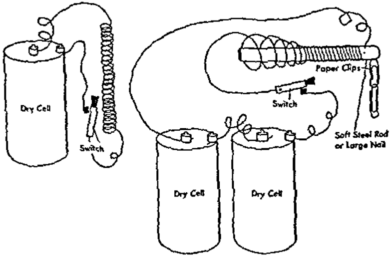
ELECTROMAGNETS.—The Field Research shows that an electric current passing through a wire will produce magnetism. This principle can be used to make an *electromagnet*. The word, as you can see, is a combination of *electric* and *magnet*.

To make an electromagnet, wind about twenty or thirty turns of insulated copper wire around a pencil. Slip the pencil out, and you have an electromagnet. If you connect the ends of the wire to a dry cell, and bring a compass needle close, you will find that it acts like a bar magnet. One end of the coil will attract the N pole of the compass needle. The other end will



Effect of Direction of Current.—The two coils of wire are the same. The *same amount* of electricity flows through each. Only the direction of the current is different. Notice the arrows which show the direction the current is moving. How does the direction of the current affect the poles of the electromagnet? How do you know?

How may the strength of an electromagnet be increased?



The electromagnet is one of the most useful pieces of electrical equipment. There are many, many different kinds. The electromagnets you will make in this experiment are simple, but they operate on the same principle as all electromagnets. Why is it important to use insulated wire? Why is copper wire better than steel wire?

WHAT TO USE.—A soft iron rod or a large nail (about 5 inches long, ¼ inch in diameter; 6 feet of insulated copper wire; a switch; two dry cells; paper clips, compass.

WHAT TO DO.—1 Wind about twenty turns of wire around a pencil. Slip out the pencil Connect the ends of the wire to the switch and one dry cell as shown in the diagram.

2. With the switch open, place the compass near one end of the coil. Close the switch. Observe the compass needle Try to lift paper clips with the coil.

3 Slip the iron rod or nail into the coil of wire. Connect to one dry cell and note the effect on the compass needle. Try to lift paper clips with one end of the rod

4. Add another twenty turns of wire to the coil. Connect to the dry cell, and observe the magnetic strength.

5. Connect in the second dry cell as shown in the drawing Note the effect of adding a stronger electric current.

What Happens.—1–2. Was there any magnetic force coming from the coil when the switch was open? How do you know? Was there any magnetic force when the switch was closed? How do you know?

3. What was the effect of putting the iron rod inside the coil? How could you tell?

4. What effect did the additional twenty turns of wire have on the strength of the electromagnet? How do you know?

5. What was the effect of increasing the strength of the current passing through the coil?

Conclusion.—What are three ways of increasing the strength of an electromagnet?

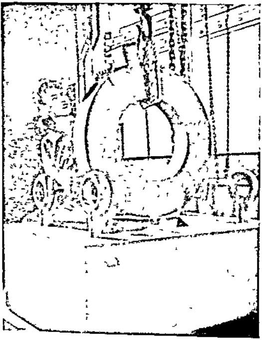
Applications.—The electromagnet shown on page 266 has more magnetic force than the one shown in the doorbell on page 270. Explain what has been done to make one stronger than the other.

attract the S pole of the compass needle. Changing the connections on the dry cell will reverse the poles of the coil of wire. Of course the coil acts like a magnet only when electric current flows through the wire.

You will find that such an electromagnet is not very strong. It will not pick up tacks and nails as does a bar magnet. But there are several ways to increase the strength of an electromagnet. One way to increase the magnetic strength is to slip a large nail or an iron rod through the core. Immediately it will have much more strength.

Another way to increase the strength of an electromagnet is to increase the number of turns of wire. The more wire that is added, the more powerful the magnet becomes. A third way to increase the strength of the electromagnet is to increase the strength of the electric current passing through the wire. Thus connecting more dry cells so that they send a stronger current through the coil will increase the power of the electromagnet. These three ways of increasing the strength of an electromagnet are described in Experiment 22. Try the experiment so that your own observations will prove these statements.

Electromagnets Are Temporary Magnets.—In your experiments with bar magnets you found that they remained



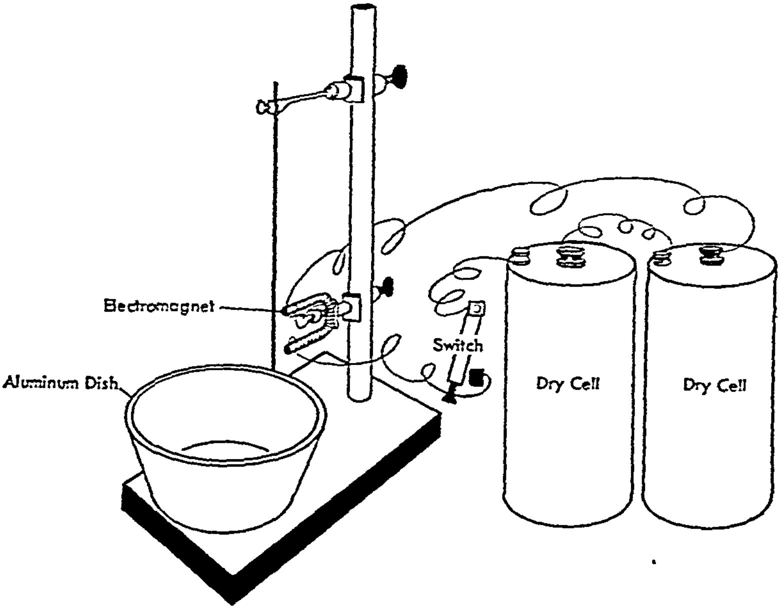
An Electromagnet.—This huge machine weighs six tons. It exerts a magnetic force equal to 40,000 pounds. It is believed to be one of the largest and most powerful magnets of its kind and could support some 200 men.

magnets, day after day, unless of course they were spoiled. Such magnets are called *permanent* magnets.

Electromagnets have a magnetic force only when electricity flows through the coil. When the electricity is shut off, the magnetism stops Thus electromagnets are *temporary* magnets. In your experiment, you may have found that the iron core in your electromagnet remained magnetized even after the current was turned off. If that happened, it was because a hard iron core was used. The core itself was made a permanent magnet. Actually, only soft iron should be used as the core in an electromagnet. The soft iron holds only very little magnetism after the current stops flowing. Such an electromagnet then is truly a temporary magnet.

Use of Electromagnets.—Two properties of electromagnets account for their wide use First, they are temporary magnets. Their magnetic power can be turned on or off at will. Second, they are easily controlled. A flip of a switch will turn on tremendous magnetic power. Another flip turns it off.

Electromagnets are used in electric bells of all kinds. One kind is the single-stroke bell. This is the type often used for fire-alarm signals in schools. You can make a model of the single-stroke bell by following the directions in the Field Research.

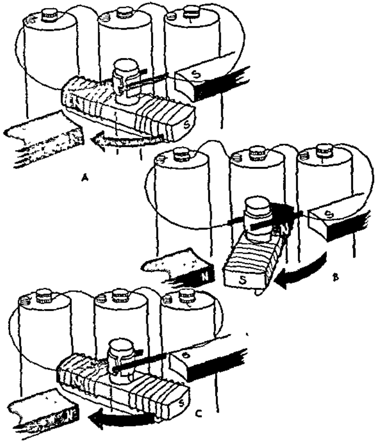


How does a single-stroke fire alarm bell work?

Bend a 6-inch length of soft iron rod (about $\frac{1}{4}$-inch diameter) into a U shape. Wind several turns of insulated copper wire around both sides of the U. Mount the electromagnet to a ring stand as shown in the diagram. Fasten a piece of heavy spring wire above the electromagnet. Place an aluminum or copper dish near the bottom of the heavy wire.

Some experimenting will be necessary to get all the parts in their proper positions. When everything is arranged correctly, closing the switch will cause the heavy wire to be drawn to the electromagnet. When the switch is opened the wire will spring away from the electromagnet and strike the dish, thus "ringing the bell."

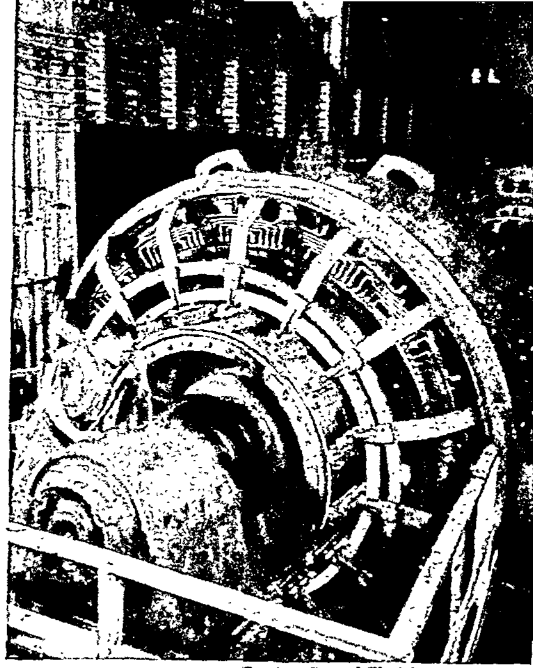
THE DOORBELL.—The common doorbell is somewhat similar in principle to the single-stroke bell described in the preceding Research. The doorbell, however, is made so that the bell continues ringing as long as the switch is closed. This means that there is a sort of automatic switch inside the door-



An Electric Motor.—As you study this diagram, refer to the text. From A to C the armature has made a half revolution. Why does the armature spin in the direction shown by the arrows? The poles of the armature changed in between diagram B and diagram C. What caused the poles to change? How could this motor be made to operate more smoothly and with more power?

Current from the dry cells passes along the wire strips and into the armature by means of a *split ring*. The electricity produces magnetic poles in the armature. These poles are either attracted to or repelled by the poles of the outside magnets.

In diagram A, the nearest poles are alike; hence they repel each other. The armature is therefore pushed in the direction shown In diagram B, the nearest poles are unlike. They attract each other. Hence the armature is pulled along in the direction shown. In diagram C, notice that the copper strips now touch the opposite split rings. The result of this is to reverse the flow of electricity in the armature. This changes the poles of the armature. The pole which just a fraction of a turn before had been S is now N. Again the armature is pushed because like poles repel. And so the armature spins around and around. Every half turn, the poles of the armature are reversed. This is made possible by the split ring arrangement. By changing the poles of the armature every half turn, it is possible to keep the armature spinning.



Courtesy General Electric

A Power Giant.—This 4,000 horsepower electric motor was built for use in a steel mill. Note the many brushes used to carry electric current to the armature. You can see the stationary electromagnets inside the motor.

What happens just in between diagrams B and C when the copper strips are at the split part of the split rings? At this point no electricity flows through the armature. But the speed of the armature carries it past this position on to the one shown in diagram C.

Commercial motors are not as simple as the one we have been studying in the diagram. They are made more powerful by having more windings on the armature. Indeed the armatures have many electromagnets instead of just one. The split ring is broken into several pieces. Instead of copper strips to carry the electricity to the split ring, carbon brushes are used. All these changes make the motor run more smoothly and more powerfully. Also, the magnets on the outside are electromagnets, instead of bar magnets as we showed. The magnets on the outside, however, do not change their poles. Only the poles of the armature change

GENERAL PROBLEM 3

How Is Electricity Generated?

ELECTRICITY FROM MAGNETS.—So far in this topic we have learned how electricity may be used to make magnetic force. It is also possible for magnetic force to be used to generate electricity

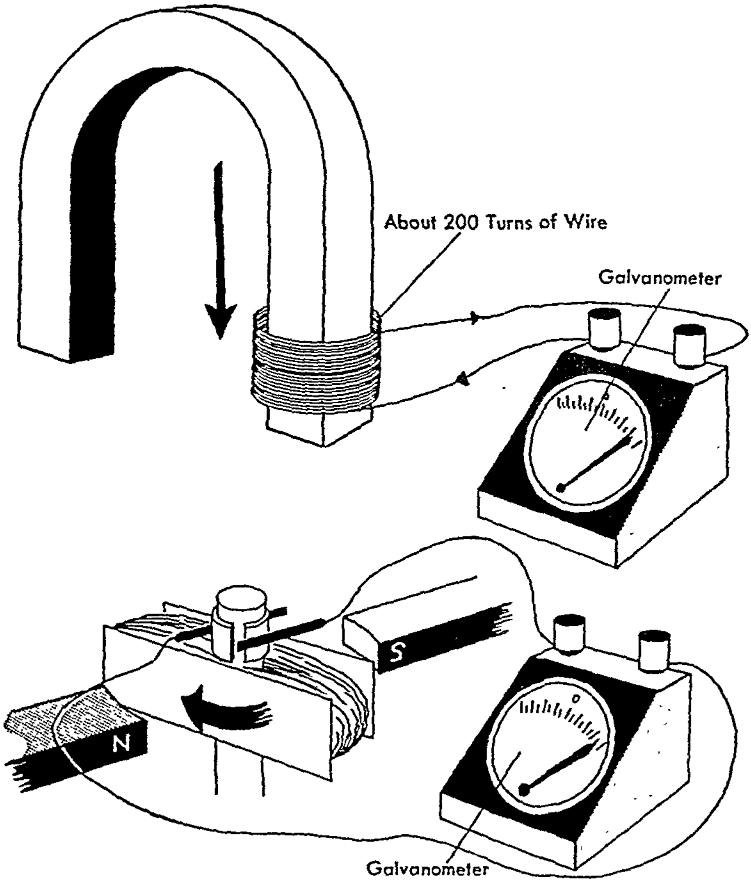
You know that there are magnetic lines of force around a magnet You have proved this in Experiment 21. If a wire is passed through these lines of force, an electric current flows along the wire. This is the basic principle which explains how electricity is generated.

The drawings, page 275, show that in one respect a generator is the reverse of an electric motor. In the motor, electricity supplied to a coil of wire (armature) mounted inside a magnetic field will cause the coil to rotate. In a generator, a coil of wire (armature) rotating inside a magnetic field will cause a current to flow through the wire.

Again in generators, split rings and copper strips or carbon brushes are used—this time to take off the electricity generated. Commercial generators are more complex than those shown in the drawings. In most generators, the armature is made up of many coils of wire. Some generators are built so that the current produced always flows in the same direction. This is called *direct current*. Direct current is produced by automobile generators. The large generators which produce electricity for our homes are usually made to send out *alternating current*. Alternating current flows first in one direction, and then in the opposite direction. Current that changes its direction 60 times a second is called 60 cycle A.C. (alternating current).

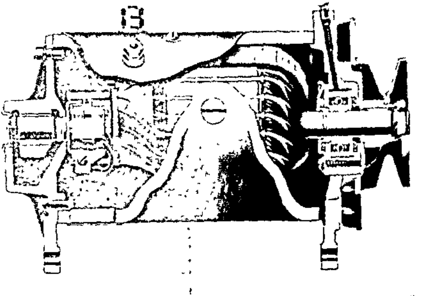
POWER FOR TURNING GENERATORS.—We have learned that an electric current is produced when a coil of wire is rotated within a magnetic field. It is also true that generators may be built so that magnets are rotated and the coils of wire remain stationary. Indeed, most of the large generators which supply our electricity are of this type.

In either type of generator, some force must be used to turn one part of the generator very fast. At present the force of expanding steam and rapidly moving water are most commonly used to spin giant generators.



Principle of the Generator.—These diagrams show the relationship between magnetism and electricity. In both cases, electricity is generated when a coil of wire cuts across a magnetic field. These diagrams show two ways this may be done. Which do you think is more like commercial generators?

Steam-powered Generators.—More than half of all the electricity produced in our country comes from generators turned by steam. Great quantities of coal are burned to form

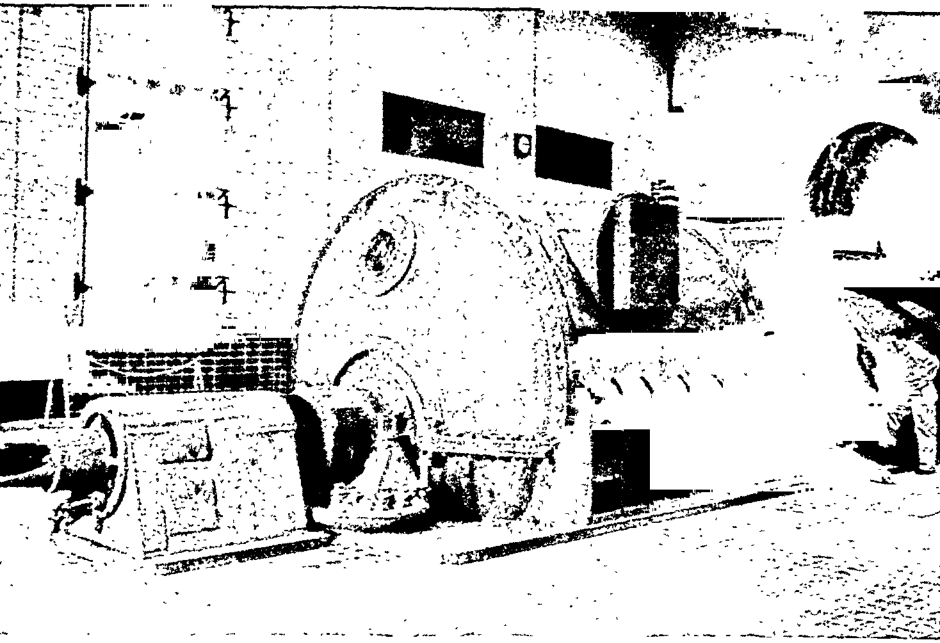


Courtesy Electric Auto-Lite Company

An Automobile Generator.—This type of generator supplies 6-volt direct current to the automobile electrical system. The stationary *field magnets* (electromagnets) are fastened to the inside of the frame. A belt connected to the motor spins the pulley. Thus the armature spins, and electric current is generated. The current flows to the split rings, through the brushes, and is carried to the terminal posts shown on top of the generator.

steam under pressure. The steam (picture on page 277) is released against a *turbine* which drives the generator. Some ocean ships are powered by electricity. In these ships, oil is burned to change water to steam. The steam drives a turbine which spins a generator. The electricity from the generator is used to turn motors which in turn drive the propeller. This may seem like a very "round-about" process, and indeed it is. The advantage lies in the fact that electricity is easier to control than is steam

Hydroelectric Power.—Perhaps you know of powerhouses where the force of moving water is used to spin turbines and drive generators. Niagara Falls, Grand Coulee, Hoover Dam, Shasta Dam, and Roosevelt Dam are just a few of the

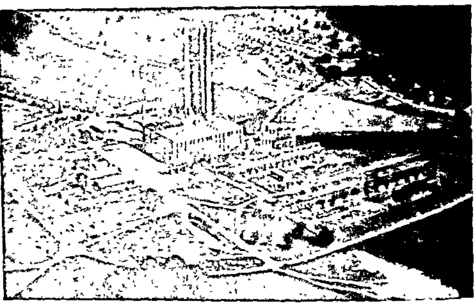


Courtesy Westinghouse

Steam Turbine Generator.—At the right, near the man, is the steam turbine. Inside the case high pressure steam is directed against thousands of steel blades. The spinning turbine drives the generator, the large machine in the center of the picture. The generator produces enough electricity to serve more than 35,000 homes.

large hydroelectric plants in our country. There are many others, scattered about wherever running or falling water exerts enough force to spin turbines. Actually, if all the water power in our country were put to work, it would generate almost twice as much electricity as we now have from all sources. The diagram on page 148 shows how water power is used to generate electricity.

Using Motors to Generate Electricity.—Any force that will spin a generator can be used for making electricity. Modern diesel-electric locomotives use diesel engines to turn generators. The electricity from the generators runs motors which turn the wheels. Diesel engines are used because they are more powerful than gasoline engines, and diesel fuel is cheaper than gasoline. Again, electricity is used to drive the locomotive because it is more easily controlled than the power directly from the diesel engine.



Texas Power & Light Company

Steam Electric Generating Station.—This plant generates 187,800 kilowatts of electricity. Remember that one kilowatt is 1000 watts. Where is the coal burned? How do you know? How is the burning coal used to generate electricity? The rows of electrical equipment at the right of the plant are transformers. They change the electricity to the proper voltage for transmission.

Electric Plants on the Farm.—Even though a farm is not supplied with electricity from a power company, it can still have the convenience of electricity. A "home electric plant" may be installed. Such plants usually consist of a generator, a gasoline or diesel engine to drive the generator, and batteries to store some of the electricity. If there are rather steady winds in the region, a wind-driven generator may also be used to furnish electricity.

Atomic Power.—The greatest source of power for generating electricity is locked up in atoms—atomic power. So far, this is power for the future

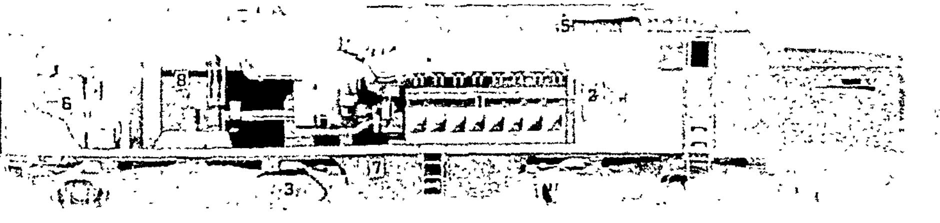
How could atomic power be used for generating electricity? The drawing on page 281 shows that heat from the "atomic pile" could be used to change water into steam. The rest of the drawing is familar—the steam is directed against a turbine which spins a generator.

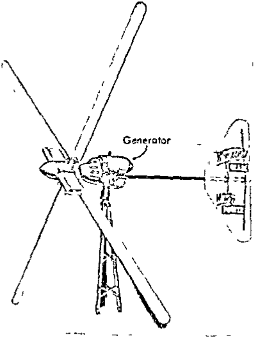
Great Northern Railway

Diesel-Electric.—Diesel engines of 5,400-horsepower are used to spin generators in this locomotive. The electricity generated is used to run the electric motors which drive the locomotive. Why are not the diesel engines used to drive the locomotive directly?

To understand how the atomic pile supplies heat is more difficult. You must remember that all elements are made of atoms. Furthermore, atoms are made of a central part called

Inside a Diesel-Electric Locomotive.—No. 1 is the 16-cylinder diesel engine; No. 2 is the main generator; No. 3 is one of the electric motors which drive the locomotive; No. 4 is the supercharger for the engine; No. 5 shows the blowers; Nos. 6 and 8 are part of the steam system for heating the cars; No. 7 is the fuel tank.





Courtesy Wincharger Corporation

Electricity from the Wind.—This wind-driven generator may be mounted on top of a barn or tower. As the wind turns the propeller blades, the armature inside the generator spins. This generates an electric current. The current is carried by means of wires (not shown) to batteries where it is stored for use. What is the purpose of the wind vane?

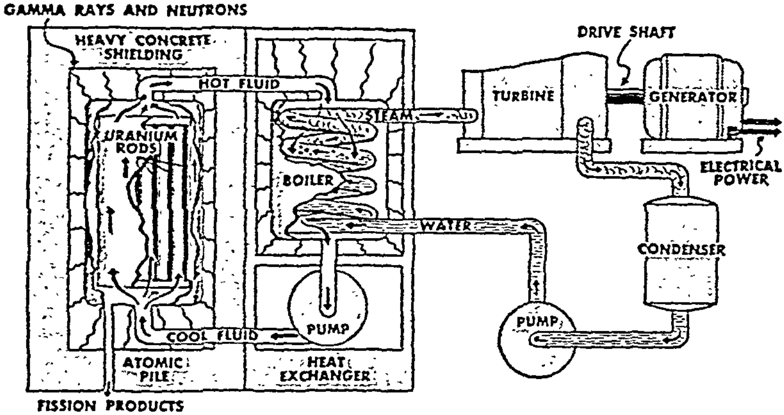
the *nucleus*, surrounded by *electrons*. You may think of the solar system for comparison. The nucleus of the atom is the "sun." The electrons are the "planets."

For a long time scientists believed that the nucleus of the atom was held together with tremendous forces. If the nucleus could be broken apart, or "split," enormous energy would be released. But for most atoms it took more energy to split the nucleus than was obtained from the splitting!

Finally it was discovered that uranium-235, a very rare twin of uranium-238, would split when struck by a *neutron*. (Neutrons can be produced in a *cyclotron*. Stray neutrons also reach the earth from space) In the process of splitting, more neutrons would be formed which in turn would split the nuclei of more uranium-235, and so a "chain reaction" would be formed. See the drawing on page 282. After much experimentation, a way was found of separating uranium-235 from uranium-238. Also another new element, *plutonium*, was made which split easily, like uranium-235

In making the atomic bomb, the plutonium was arranged so that an extremely fast chain reaction would occur. All the energy was released in a fraction of a second. The result was a tremendous explosion.

The peacetime use of atomic energy presents different



By permission of the American Education Press, publishers of "Current Science and Aviation"

Atomic Electric Plant.—In this imaginary atomic "powerhouse" a fluid is pumped through an atomic pile where it is heated. (Where does the heat come from?) The hot fluid is used to change water into steam. This happens in the *heat exchanger*. The steam is then used to spin a turbine which, in turn, spins a generator. What is the purpose of the condenser? Why is the atomic pile enclosed in a thick concrete shield?

problems. The main problem here is to slow down the chain reaction so that a steady and controlled amount of heat will be given off. This is the purpose of the "pile," but as yet it is not completely practical. Another problem has to do with *radiation.* When the nucleus of plutonium or uranium is split, dangerous invisible rays are given off. These rays pass through all materials except very thick concrete or lead. Thus everything near the pile, including the pipes, water, turbines, steam, and generators somehow must be protected from the radiation.

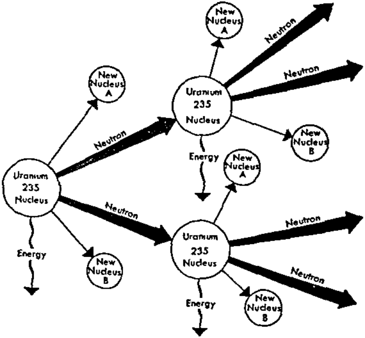
The problems involved in using atomic energy for generating electricity are great. But the rewards for solving the problems are even greater. It has been estimated that one pound of uranium-235 can produce energy equal to 3,000,000 pounds of coal. One of the best ways of using this energy seems to be to change it into electricity in future "atomic-electric" plants.

Thinking Things Over.—From lodestone to atomic energy to spin generators—this has been the story of magnetism and electricity. We know that magnetism is not completely understood. Yet enough is known about magnets and how they act to make them very useful

We have learned that the force of a magnet is strongest at its poles We have also learned that the poles of a magnet attract each other if they are unlike. They repel each other if they are the same.

Whenever an electric current flows through a wire, a magnetic field is set up about the wire. Thus it is possible to make electromagnets These are temporary magnets. Bar magnets and horseshoe magnets are permanent magnets.

Electric motors and generators are similar in construction. But they are opposite to each other in what they do. Motors



Chain Reaction.—This diagram shows what happens during a chain reaction. What causes the uranium-235 nucleus to split? What happens each time a nucleus of uranium-235 is struck by a neutron? Where do neutrons come from? The process shown here may take place instantaneously Millions of uranium nuclei may split in a tiny fraction of a second.

spin when electricity flows through the motors. Generators produce electric current when they are turned by some force. Most of our electricity is made by generators turned by steam or by moving water. In the future, steam produced by the heat of atomic piles may be used to spin generators.

Key Words

armature	lines of force	plutonium
atomic pile	lodestone	poles (magnetic)
chain reaction	magnet	temporary
compass	motor	turbine
electromagnet	neutron	uranium
generator	nucleus	
hydroelectric	permanent	

Key Statements

1. Magnets are objects which attract certain other materials.
2. Magnetic force is the strongest at the poles of a magnet.
3. The magnetic force leaving a magnet forms lines of force.
4. One pole of a magnet is called the north pole. The other pole is called the south pole.
5. The magnetism of the earth causes a compass needle to point in a north-south direction.
6. The end of a compass needle which points toward the north is called the north-seeking or north pole of the compass.
7. Like magnetic poles repel each other. Unlike poles attract each other.
8. An electric current flowing through a wire forms a magnetic field around the wire.
9. A coil of wire through which an electric current passes is a temporary magnet. It is called an electromagnet.
10. An electromagnet's strength may be increased by increasing the turns of wire, placing a soft iron core in the coil, and sending a stronger current through the coil.
11. In the electric motor, an armature or electromagnets are mounted between other magnets. As the direction of the current flowing into the electromagnets is changed, the poles of the electromagnets are changed. Thus the poles of the electromagnets are first attracted to and then repelled by the poles of the outside magnets. This causes the armature to rotate.

12. When a wire is moved through a magnetic field, an electric current moves through the wire This is the principle of the electric generator

13 Most of the electricity in the United States is produced from steam-driven generators

14 Hydroelectric plants use the force of running water to turn generators.

15 Great quantities of electricity may someday be made by generators driven by atomic power.

Thought Questions

1. How do you know that the earth is a magnet?

2 Is magnetism a form of electricity? Give reasons for your answer

3 What is a lodestone?

4 Where is most of the force of a magnet concentrated? Give proof for your answer

5 How could you tell which end of a magnet was the south pole?

6 Why does a magnetized needle point in a north-south direction?

7 How would three south poles of three magnets act toward each other?

8 What is a magnetic field?

9 How are the poles of the electromagnets in the armature of a motor changed? What is the effect of this?

10 List three ways the strength of an electromagnet may be increased.

11 What is the principle of the electric generator?

12 Describe the chain reaction which takes place when the nuclei of uranium-235 atoms are split

Projects for Your Science Discovery Book

1 Go to the library and read about some of the early uses of lodestones. Write a brief report in your Science Discovery Book.

2 A magnetic screw driver is handy for use with small screws. Magnetize a screw driver by rubbing the blade in the same direction with one pole of a strong magnet.

3 Magnetize five needles so that the eyes of all five are the same pole Insert each needle into a flat cork so that half the needle is above the cork Float all five with the eyes out of water. Explain the arrangement of the corks

4. Make an electromagnet by winding many turns of insulated wire around a bolt and nut with a washer at each end. Connect it to a dry cell. Test its strength. If a stronger magnet is wanted, add more turns of wire.

5. Examine the electromagnet couplers on some model electric trains. Show by means of drawings how they work.

6. Try to find a discarded doorbell for study. Take the cover off and trace the wiring. Pay particular attention to the work of the contact points.

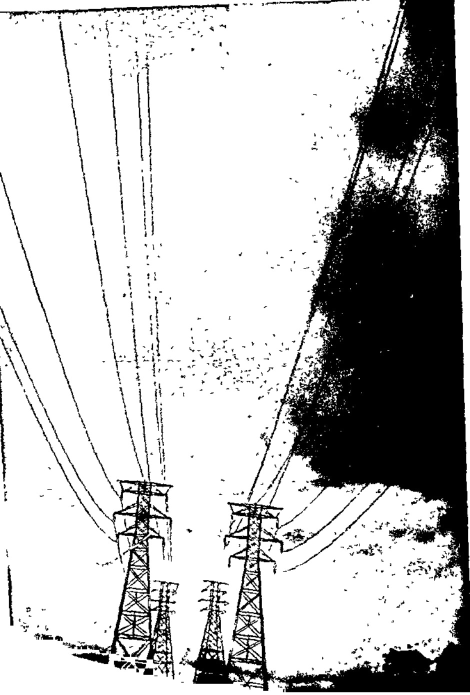
7. Find out where the electricity used in your home is generated. What is the source of power used to turn the generators?

8. Make a report on one large hydroelectric plant. How many generators are used? How much electricity is produced? How much water is needed? How fast does the water move?

9. List all the uses of electricity in your home.

10. Make a simple galvanometer. Carve out a hole in a block of wood for a small compass. Set the compass in the hole and wind 60 or 70 turns of very thin insulated wire around the block and compass. The winding should all be in the same direction, and should be tight enough to hold the compass firmly in the hole. Fasten the ends of the wire to two bolts and nuts as terminal posts. Glue bits of felt on the corners underneath so that the block is steady.

To use the galvanometer, turn it so that the compass needle is parallel to the wire. Whenever a slight electric current flows through the coil, the compass needle will move.



Courtesy Westinghouse

Electrical Highways.—Transmission lines like these are the electrical highways of the air. Pushed by 66,000 to 132,000 volts (or even more), electrical energy whizzes along the copper skin of the steel wires.

TOPIC XI

Electricity and Communication

DO YOU KNOW—

1. What radar is?
2. The Morse code?
3. Whether your voice is carried along telephone wires?
4. Some different kinds of microphones and their uses?
5. That there is an electron gun in your television set?
6. How to make a telegraph set?

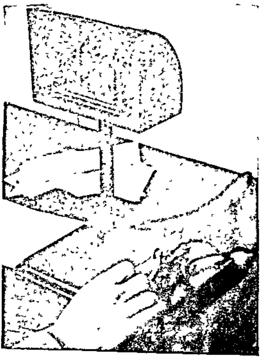
GENERAL PROBLEM 1

How Are Messages Carried by Telegraph and Telephone?

USEFUL ELECTROMAGNETS.—In Topic X we studied about electromagnets. We discovered that electromagnets make possible electric motors. We know that such magnets are also used to lift great weights of iron or steel.

Electromagnets are important in communication. Indeed, the telegraph, the telephone, and the teletype all use electromagnets to carry messages from place to place.

TELEGRAPH.—A little more than 100 years ago, Samuel F. B. Morse made the first telegraph set in the United States. Today there are more than two million miles of telegraph lines


Ewing Galloway

Tapping Out a Message.—This old Western Union telegraph set has been replaced in most areas with modern teletype machines The telegraph is still important, however, in many smaller stations. (Compare this picture with the one on page 289.)

in operation. Almost every city, town, railroad station, and airport are connected by means of telegraph.

The telegraph system consists of a sending key and a *sounder*, connected by wire through which an electrical current may flow. The key is really a switch When the key is pressed, it closes the switch, and electricity flows through the wire to the sounder.

The sounder is an electromagnet. When current flows through the electromagnet, a small iron bar or lever is drawn to the electromagnet. As the lever strikes the core of the electromagnet, a "click" is heard. When the pressure is taken off the sending key, the switch opens, and the current stops flowing through the wires. The electromagnet in the sounder becomes demagnetized. A spring on the metal lever pulls it away from the core, and against a metal frame. As the lever strikes the frame, another "click" is heard Thus every time the telegraph operator presses on the sending key, a click is heard from the sounder. Every time the operator releases the sending key, another click is heard.

In order to send messages by telegraph, a *code* must be used. A very short space between two clicks is called a "dot" A longer space between two clicks is called a "dash." Combinations of dots and dashes stand for the letters of the alphabet. For example, the letter "A" in the Morse code is "dot," "dash."

The letter "B" is "dash," "dot," "dot," "dot." The complete Morse code is given in the Appendix.

You can make a two-way telegraph set at home by following the directions in Experiment 23. Notice that a lock switch makes it possible for either instrument to be used as a sending key or as a sounder.

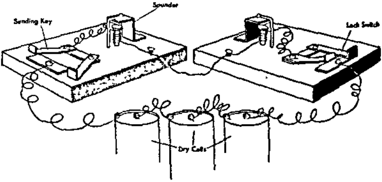
The telegraph set you make in Experiment 23 can send only one message at a time over the wire. Modern telegraph systems can send many different messages over the same wires at the same time. Using a combination of methods, 120 messages may be carried at the same time on 4 wires.

TELEGRAMS AND TELETYPE.—In the old days telegrams were sent by code as described on page 288. An operator sent out the "dots" and "dashes" to the distant station. There

A Modern Telegram.—The girl is operating a teleprinter. As she "types" out the message, holes are punched in the paper tape. The tape leaves the teleprinter and passes through the automatic transmitter at her left. The transmitter sends out an electrical current which operates an automatic teletypewriter at the receiving station.

(HOME) EXPERIMENT 23

How does the telegraph operate?



This experiment makes use of electromagnets. In what other experiment did you make an electromagnet? Before trying this experiment, trace the flow of electricity through the apparatus. What is the purpose of the lock switch on each sending key?

WHAT TO USE.—Two blocks of soft wood about 1" × 4" × 8"; old "tin" cans or sheet metal, tin snips or metal shears; about 20 feet of No 20, 22, or 24 insulated copper wire; about 25 feet of ordinary insulated doorbell wire, two dry cells, two steel wood screws about 2" long, two finishing nails about 3" long, several ½" wood screws.

WHAT TO DO.—Use the tin snips to cut the sheet metal in strips as shown Assemble the telegraph set as shown in the drawing. You will have to experiment to make sure the strips on the sounders are bent just right so that they click when they are pulled down, and click when they spring back and strike the nail

Move one set as far from the other as possible. Close the lock switch of one set and operate the key of the other set Observe what happens to both sounders Try using the other set as the sender.

WHAT HAPPENS.—1 Trace the flow of electricity when one sending key is pressed

2 How many sounders operate when one key is pressed? Why?

3 When is the metal strip of the sounders pulled to the electromagnet? When does it spring back to the nail?

4 What happens when the lock switch of a sender is closed?

5 How is a set changed from a sounder to a sending set?

CONCLUSIONS.—1. What is the purpose of the key in a telegraph set?
2. How does the telegraph sounder operate?
3. Explain in your own words how the telegraph set operates.

APPLICATIONS.—Of what value is the telegraph in the operation of railroads?

Why has the teletype replaced the telegraph set for telegrams?

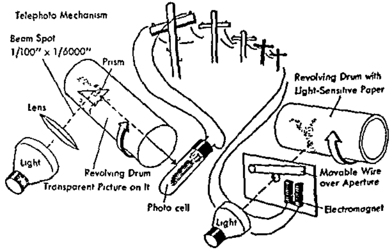
the operator translated the message from the code, and typed it on a telegram which the "telegraph boy" delivered.

The modern system of sending telegrams makes use of teletypewriters, or "teletype machines" as they are sometimes called. The sending operator types out the message on the teletypewriter. Two things happen as the operator types out the message. A regular typewritten copy of the message is made. This the operator keeps as a record of the message sent. At the same time the machine punches combinations of holes in a paper tape. As this paper passes through another part of the machine, electrical contact fingers touch the tape where the holes are. This sends out electrical current over the wire in the same spurts as the holes are in combination in the paper.

At the receiving end of the line the spurts of current cause the same letters to be written on an electrically operated typewriting machine. The message is typed on a tape which comes out of the side of the teletype machine. The operator cuts off the pieces of tape and pastes them on a telegram form. The telegram is then phoned or delivered.

SENDING PICTURES BY TELEGRAPH.—For the past 15 years many newspapers have been receiving pictures by telegraph. A picture taken in San Francisco, may be "telegraphed" to New York, and appear in the newspaper, all within a few hours. Sending the same picture by mail would take two or three days.

The diagram on page 292 shows how pictures are sent by telegraph. The photoelectric cell is a device which changes light energy into electrical energy. It is sometimes called an "electric eye." Photoelectric cells may be used to open or close



Sending Pictures by Electricity.—The diagram is simplified to show the main parts of the apparatus used to send pictures by telegraph. The picture to be sent is on the drum at the left, and is being received on the drum at the right. What is the purpose of the prism? What does the photoelectric cell do? How is the size of the hole (aperture) controlled? What happens when the aperture is completely closed?

doors when a beam of light is broken. They may also be used to turn on drinking fountains.

The picture to be sent by telegraph is a transparent film, something like a photographic negative. It is mounted on a cylinder which revolves A tiny beam of light is focused on the picture. As the picture revolves, gradually every tiny section of the picture falls under the beam of light. As shown in the diagram, the light travels through the picture, and is reflected into a photoelectric cell. Little or no light passes through the dark sections of the picture. All of the light passes through the light sections of the picture. Thus varying amounts of light reach the photoelectric cell And these varying amounts correspond to the same pattern of lightness and darkness in the picture.

The photoelectric cell sends out an electric current which varies with the light which reaches it. This varying current is sent along wires to the receiver. The current operates an elec-

Courtesy RCA

Radiophoto.—One step beyond telephoto is radiophoto—the sending of photos by radio waves. This photo of the governor of Bermuda was the first picture to be sent by radiophoto from Bermuda to New York. A picture of the message he is writing was also sent.

tromagnet which controls the size of a tiny hole through which light is passed. The light falls on a photographic film mounted on a turning cylinder. The light which reaches the film corresponds to the light which passes through the original picture. After the beam of light has traveled the length of the cylinder, the film is removed and developed.

TELEPHONE.—The telephone, like the telegraph, carries messages by wire. The telegraph, however, can send only a coded message. The telephone makes it possible for you to hear the words spoken by another person.

You will remember that there is no change in the current sent along telegraph wires. The current is "on," or it is "off." In the telephone an electrical current of changing or varying strength is carried along wires. This varying current is the secret of the telephone.

SOUND WAVES.—You learned in an earlier science course

Courtesy Westinghouse

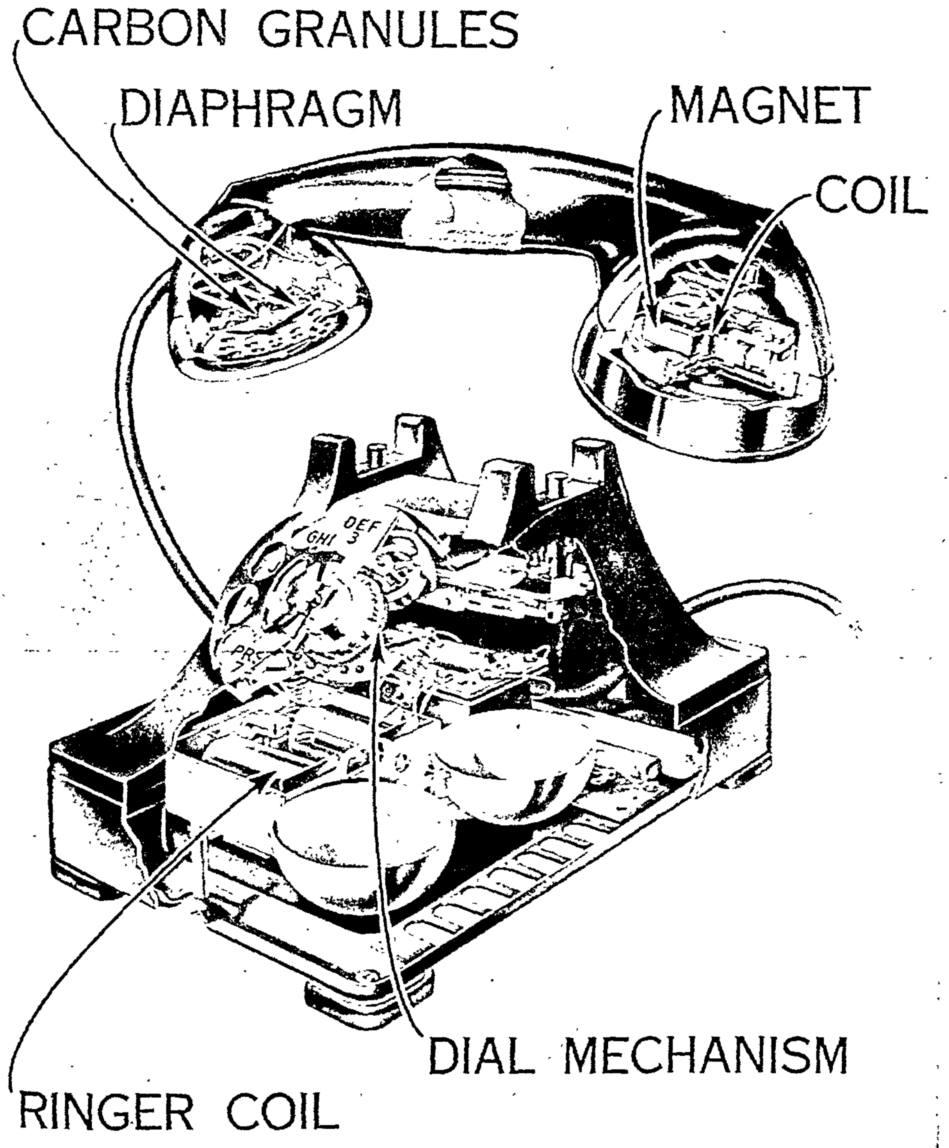
Controlling a Door with an "Electric Eye."—A beam of light from a bulb on the left-hand railing shines on a photoelectric cell behind the right-hand railing. When a person breaks the beam of light, the electric eye stops sending current. This break in the current is made to operate a switch which turns on a motor to open the door.

that sounds are *vibrations*. Any object that vibrates produces sound. And sounds may be carried by any matter that can be made to vibrate.

When you talk your vocal cords vibrate. Their vibrations set the nearby air molecules vibrating. These molecules in turn set other air molecules vibrating, and so the sound of your voice is carried.

FROM SOUND WAVE TO THE ELECTRICAL WAVE.—When you talk into the mouthpiece of a telephone, the vibrating air molecules strike a thin *diaphragm* in the transmitter. The diaphragm is set vibrating. In back of the diaphragm is a small box containing carbon grains. The back and forth movement of the diaphragm alternately squeezes the grains together, then allows them to spread apart.

An electrical current passes through the carbon grains. When the grains are pressed together they are a good conductor of electricity, and a strong current flows through. When the pressure is released, they are a poorer conductor, and a weaker current flows. This variation in electrical current has the same pattern as the sound waves reaching the diaphragm. Thus the transmitter changes sound waves into corresponding electrical waves. These variations in electric current are then carried by wires to the telephone receiver. Try Experiment 24 if you can obtain the necessary materials. The experiment will help you understand the changing strength of current in telephone wires.

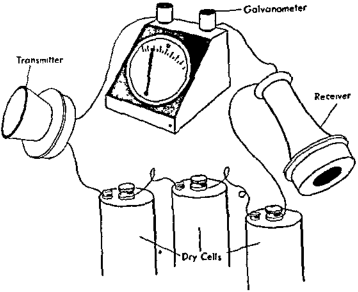


A. T. & T. Co.

Modern Telephone Set.—The important parts of a telephone are shown in this cutaway diagram. Other telephones may look somewhat different from this one, but each has a transmitter and a receiver. What is the purpose of the carbon granules? How does the receiver change an electric current to sound waves?

EXPERIMENT 24

What happens to the current in a telephone circuit when sounds enter the transmitter?



If you do not have the equipment to try this experiment, study the diagram carefully Trace the flow of electricity through the wires and the instruments What happens to the electric current in the transmitter? in the receiver? What is the purpose of the galvanometer? In what ways is an actual telephone installation more complicated than this diagram?

WHAT TO USE —A discarded but usable telephone transmitter and receiver, two or three dry cells, a galvanometer

WHAT TO DO —1 Connect the transmitter, receiver, dry cells, and galvanometer in series as shown in the diagram Turn the galvanometer so that the class can see the needle. With the room quiet, observe the needle

2 Have one person talk into the transmitter, and another listen through the receiver Observe what happens to the needle of the galvanometer.

3 Compare the action of the needle when the person talks loudly and softly

NOTE —If the listener cannot hear through the receiver, try adding more dry cells

The galvanometer needle moves off zero whenever an electric current flows through the circuit. If it moves to a position and stays there, a direct current of constant strength is flowing through the wires. The *stronger* the current, the *farther* the needle will move.

WHAT HAPPENS.—1. Did any current flow through the circuit when the room was quiet? How do you know? If there was a current, was it steady or did it change in strength? How do you know?

2. Could the listener hear the message through the receiver? What happened to the galvanometer needle when words were spoken into the transmitter?

3. What happened to the needle when words were spoken loudly into the transmitter? When words were spoken softly into the transmitter?

CONCLUSIONS.—1. What happens to the current in a telephone circuit when sounds enter the transmitter?

2. How does the strength of the electrical current carried by the wire compare with the loudness of the sounds spoken into the transmitter?

3. Where is the beginning of the variations in the strength of the current flowing through the telephone wires?

FROM ELECTRICAL WAVES TO SOUND WAVES.—The receiver is a permanent magnet, the ends of which are also electromagnets. A thin metal diaphragm is held in place by the permanent magnet. (See drawing on page 295). The electrical waves travel through the electromagnet. As you learned earlier, the strength of an electromagnet is affected by the strength of the current flowing through it. Thus the electromagnet in the receiver is constantly changing its strength. This causes the diaphragm to vibrate. And the vibrating diaphragm produces sound waves which travel through the air to your ear. Actual sounds are not carried over the wires. The electrical current carried by the wires causes vibrations in the receiver diaphragm which correspond to sounds spoken into the transmitter.

FIELD RESEARCH

If an old telephone is available, take it apart to study its parts. Find the diaphragm in the transmitter. Saw the transmitter case in half to see the carbon granules. Note where the wires are attached. Unscrew the ear piece from the receiver. Note the steel diaphragm. Remove the diaphragm. Locate the permanent magnet. Find the electromagnet which vibrates the diaphragm.

GENERAL PROBLEM 2

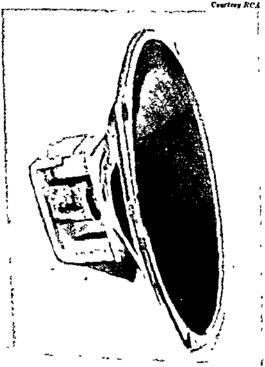
How Are Messages Carried without Wires?

PROGRESS IN COMMUNICATION.—Have you ever thought about the different kinds of communication man has used through the ages? Many ancient people used fire beacons for sending messages The Indians used smoke signals. African natives used drums. Paul Revere received his famous message as a light signal Sailors use signal flags, semaphore flags, and blinker lights All these methods were used long before electricity was discovered. Some are still used today.

With the discovery of electricity, new methods of sending messages were invented. The telegraph appeared in 1835. About 1875 Alexander Graham Bell invented the telephone. Then about 1900 Marconi invented the wireless telegraph—a means of sending a coded message without the use of wires. Some twenty years later *radio* became successful. During World War II *radar* was developed. Right after the close of World War II *television* was perfected as the newest means of communication.

Loudspeaker.—The coil which is behind the speaker is part of an electromagnet. Another coil, hidden by the frame, is part of an electromagnet which causes the black paper cone to vibrate and produce sound. (Compare this picture with the diagram of the loudspeaker on page 300.)

Courtesy RCA



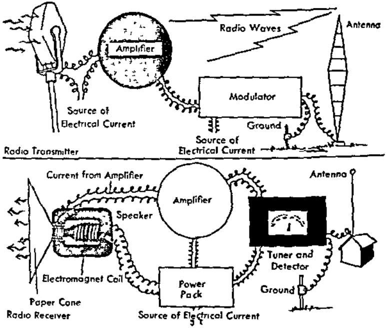
RADIO.—If you have ever looked inside a radio set, you know that radio is too complicated to be explained in this science course. Many of the details of how radio works must be left for later science study. But we can understand some of the basic principles of radio broadcasting and reception.

BROADCASTING.—The sounds in a broadcasting studio are picked up by a *microphone.* There are many different kinds of microphones for different purposes. One type is very similar to the telephone transmitter. The sound waves set a diaphragm vibrating. These vibrations affect carbon grains inside the microphone, which cause variations in an electric current. This varying electric current is sent to the transmitter which may be miles away from the studio. The current is carried to the transmitter over telephone lines.

At the transmitter the current is *amplified*, or strengthened. Then the pattern of this current is added to another powerful electric current produced at the station. This combination current passes through another part of the transmitter, and flows through the *antenna.* There it sets up radio waves which travel out from the antenna. The radio waves are in the same pattern as the current which flowed through the microphone.

Microphones.—The large microphones shown here are frequently seen in radio studios. The small microphones weigh only 12 ounces but are as sensitive and "powerful" as the large ones. For what kind of programs would the smaller "mikes" be useful?

Courtesy RCA



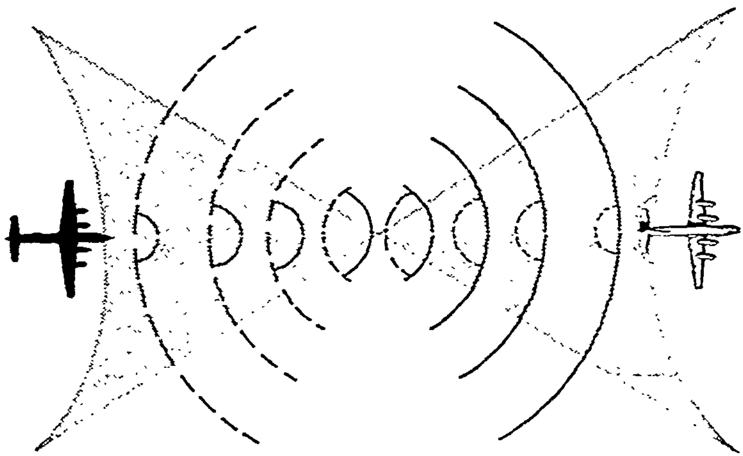
Radio.—The important parts are shown here to help you understand the principles involved in radio broadcasting and reception. Can you tell what each part does? Start with the microphone and follow through to the broadcasting antenna. Why must the electrical current from the tuner and detector be strengthened? Where is this done? Why does the paper cone in the speaker vibrate? What do the vibrations cause?

Radio Reception.—A radio receiver is made so that it changes radio waves back into a varying electrical current. The tuning knobs or push buttons on the radio set move parts of the set so that different stations may be "tuned in." The electrical current in the receiver is strengthened, and then passes to the speaker. As is shown in the drawing, the speaker has an electromagnet. The electromagnet causes a paper cone to vibrate. Its vibrations send out sound waves which we hear.

We can understand, then, the important parts of sending and receiving messages by radio The microphone changes sound waves into a varying electric current of the same pattern. The transmitter changes this current into radio waves. A receiver tuned to certain radio waves changes the radio waves into an electrical current of the same pattern. This electric current operates a speaker which sets up sound waves again.

RADAR.—The basic principles of radar were discovered some thirty years ago. It wasn't until World War II, however, that it was developed into a practical and useful instrument.

Radar makes use of radio waves, special kinds of waves known as *short waves*. Unlike usual radio waves, short waves are reflected by metal, land, and even heavy rain storms. The idea in radar is to send out bursts of short waves. If they

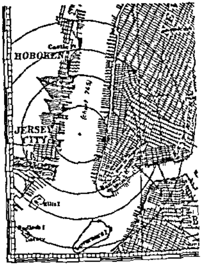


Aircraft Radar.—The black plane is sending out a radar beam indicated by the solid lines. When the beam strikes the white plane, it is reflected back to the black plane. The reflected beam is represented by the dotted lines. The distance between the planes is determined by the time it takes the beam to travel to the white plane and back again.

strike some object they will be reflected back to the radar set. Even though these waves travel at the speed of 186,000 miles per second, it is possible to determine how long it takes the waves to travel out and back.

In actual practice, the radar set has a special sort of screen, much like the screen on a television set. A single line across the bottom of the screen represents the range of the radar set, for example 93 miles. If no waves are reflected back to the set, the line remains as a straight line. If, however, the radar waves strike a ship or an airplane, a peak or a "pip" appears in the

Radar Picture.—The picture above shows a
rbor as "seen" by a radar aboard a ship The
ite dot in the center shows the position of the
ip The large white spots are land. The black
annel from top to bottom is the Hudson River.
nall white spots in the River are ships. Compare
this picture with the map on the right.

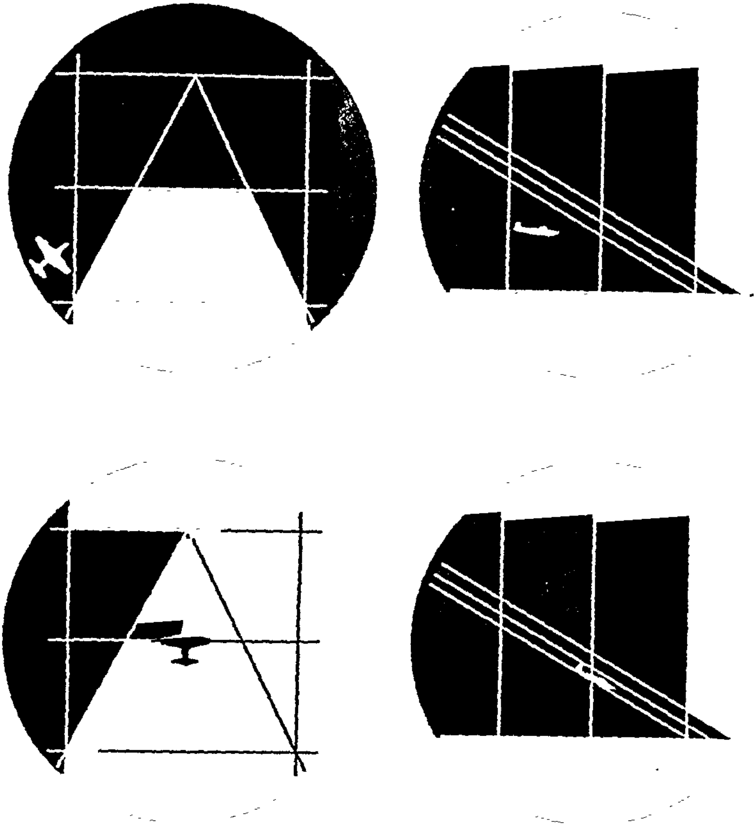


Part of New York Harbor.—This is a map of the region shown in the radar picture on the left. Compare the two pictures. Find Governors Island and Bedloe's Island in each picture Each circle on the map equals one-half mile of range from the ship.

line. If the pip is halfway across the line, the ship is $46\frac{1}{2}$ miles away (half of 93). Actually the bottom of the radar screen is marked off in miles so that the operator can tell immediately how far away the object is when he sees a pip.

Finding the *range* is half the job of radar. Finding the *direction* of the object is the other half. The radar set has an antenna which can be turned. The operator turns the antenna until the pip on the screen reaches its greatest height. Then the antenna is "on" the object and points straight in its direction.

Radar is especially valuable because it "sees" through fog or darkness. It may be used to spot airplanes long before they can be detected by sight or sound. It can be used to bring airplanes in to a safe landing when the pilot cannot see the runway. When it is installed in ships or airplanes, radar can be used to "see" dangerous conditions ahead.



Coming in by Radar.—An operator at the airport has two radar scopes. The upper left scope shows how the field looks from above. Inside the upside down V is the zone for a safe approach. The upper right scope shows a side view for approaching the field. The correct approach will be within the lines.

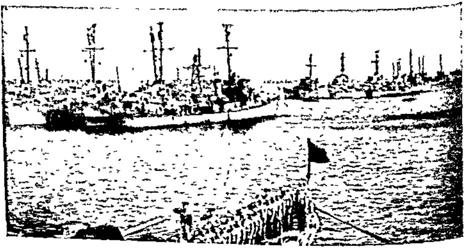
The upper scopes show that the plane is too far to the left, and too low. The radar operator on the ground radioed this information to the pilot, who corrected his approach. A minute or two later (as shown by the lower diagrams) the plane was in correct position for the approach.

During recent years there have been many new applications of radar. The *radio proximity fuse* is a miniature radar set installed in the nose of a shell. When a shell comes within a certain range of an object, the reflected radar waves set off the shell. Thus the shell "waits" for the proper instant to explode. Another application of radar is a system whereby friendly planes automatically identify each other. Still another is a system whereby a radar set can scan a region. This means that the radar set can tell a pilot about the land or ships or other objects over which he is flying.

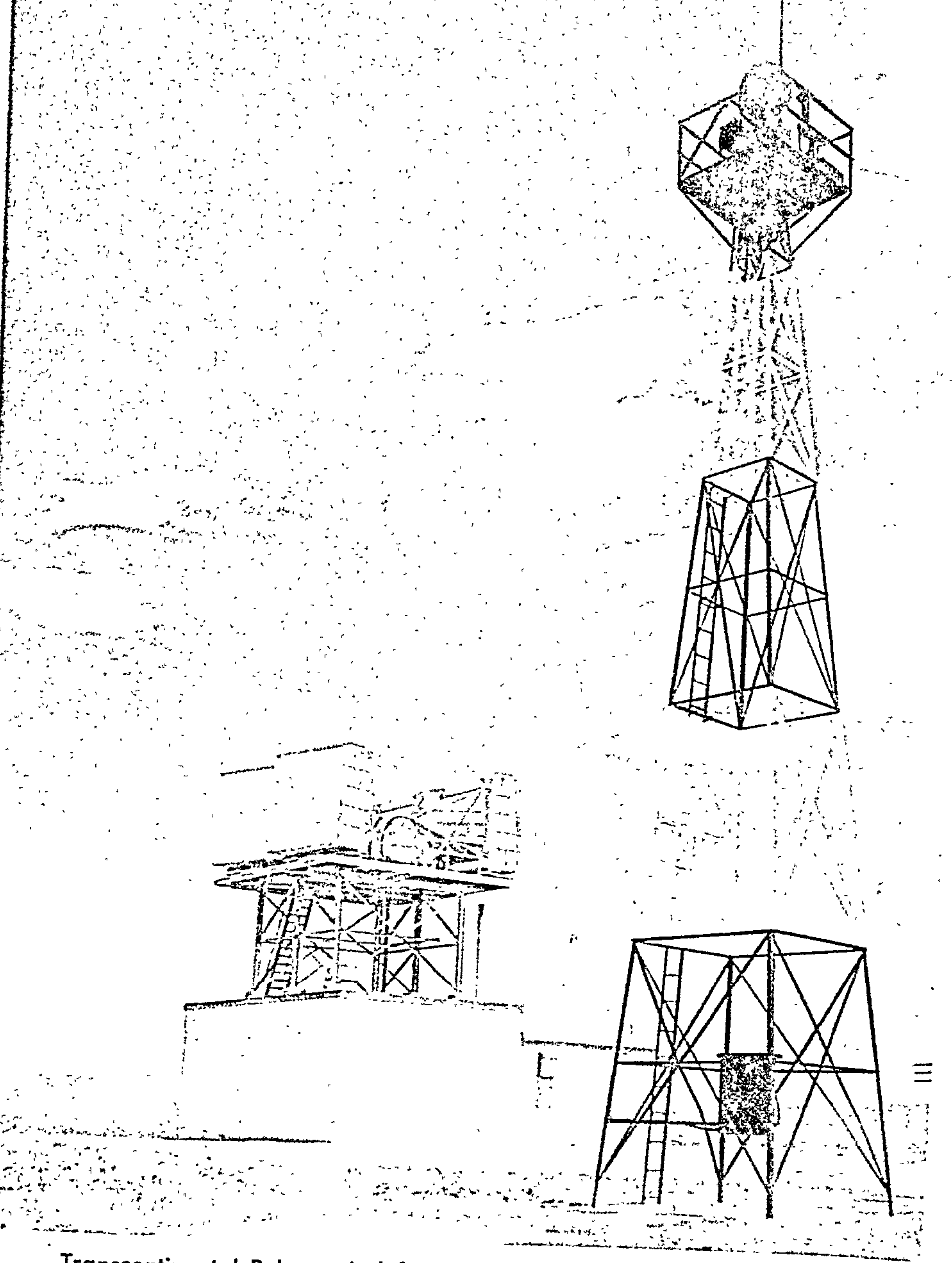
Many scientists are busy working on new applications and improvements of radar. We can be sure that many more uses will be found for this useful tool.

TELEVISION.—Few inventions have appealed to people as has television In 1945 it was something new and unusual. By 1952 it had become almost as common as radio. Television carries both sound and pictures from the transmitter to the receiving set. The carrying of sound is really a part of radio, so we shall consider now only the picture part of television.

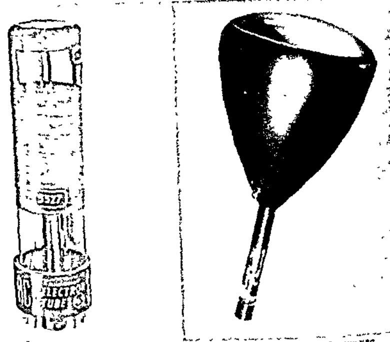
One of the basic ideas in television is to change light energy into electrical energy. Television does just this. A pattern of lightness and darkness is changed into an electrical current that varies with the pattern of the light. The details of how this is done will have to wait for a later science course. But we can understand some of the parts of television.



One Use of Radar.—The ships of our navy shown in this picture are equipped with radar. How can you tell?



Transcontinental Relay.—At left is one of the stations of the Bell System's Transcontinental Radio-Relay System, opened in 1951, and designed to carry television as well as telephone messages by radio microwaves. At each tower the microwaves are received, reinforced, and sent on to the next tower. There are 123 stations in the transcontinental radio-relay system from Boston to Los Angeles. The stations average about 28 miles apart. At right is an airplane beacon.

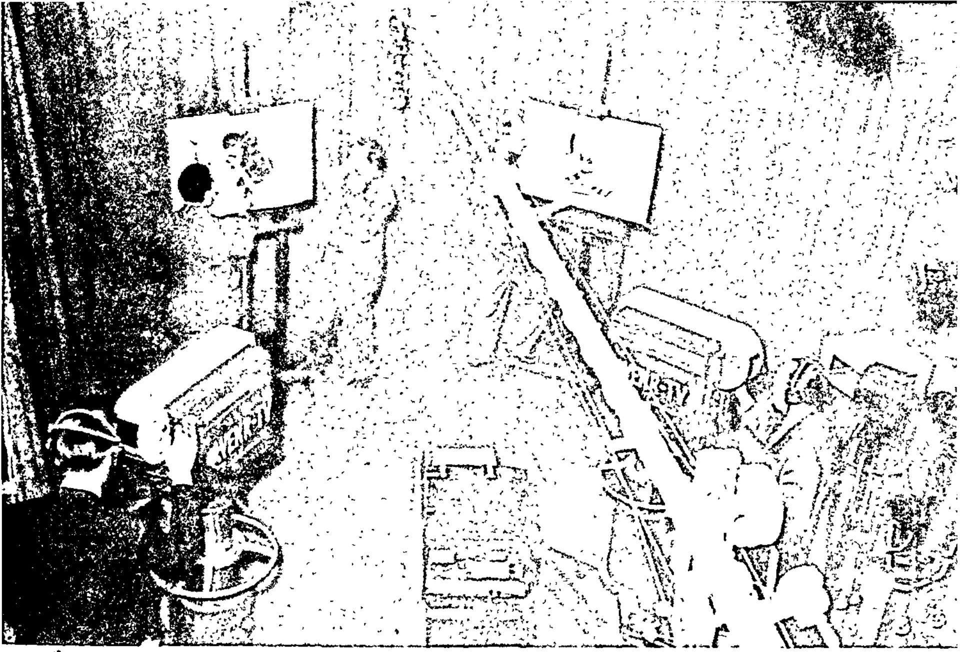


Courtesy RCA Courtesy VBC

Television Tubes.—(Left) The camera tube is the heart of the television camera. Inside the tube are the screen, target, and electron gun. Explain what each does. (Right) The top of this picture tube is the screen where the picture is formed. A beam of electrons sweeps across the screen in a pattern of 441 lines, 30 times each second. Wherever an electron strikes the screen, a spot of light appears.

TAKING THE PICTURE.—You will remember that a *photoelectric cell* is used in sending pictures by telegraph. Light falling on a photoelectric cell causes the cell to send out an electric current. A television camera uses the same idea in a special television camera tube.

Light enters the camera tube and falls on a screen. The screen is made so that electrons (charges of electricity) are given off when light strikes it. Further, the more light that reaches the screen, the more electrons that are given off. These electrons travel like bullets to a target screen. As they strike the target, they push electrons out of the target. These "pushed out" electrons are carried away, leaving the target with fewer electrons than it needs. While this is going on, an electron

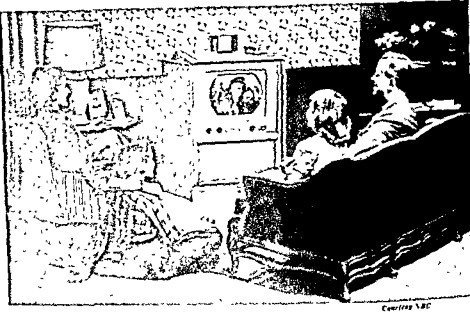


Courtesy RCA

TV Studio.—These are only part of the equipment and people needed to broadcast a television program. Note the microphone on the "boom." Two cameras are being used. The engineers in the control room see both pictures, but only one is selected to be transmitted. The engineers may change from one camera to another several times during the telecast.

gun on the other side of the target is "shooting" a rapid stream of electrons at the target. The stream of electrons is aimed at the target so that it sweeps the target in a regular pattern of horizontal lines. As the electron stream sweeps across the target, electrons are captured at those spots where the target is missing electrons. The rest of the electrons bound off the target and return to the gun. This means that there is a steady stream of electrons leaving the gun, but a varying stream that returns to the gun. The variations in the returning electron stream correspond to the light and dark parts of the object being televised.

Thus the electron stream—an electrical current—which returns to the gun is an electrical "picture" of the object. *This current is then strengthened and sent to the transmitter.* At the transmitter it is changed into radio waves and sent out



Enjoying Television—Tell how this program is brought from the studio in Chicago to a home television set.

from the antenna. The transmitter also sends out another set of radio waves which carry the sound.

RECEIVING THE PICTURE.—In the television receiver is a large tube, often called the "picture tube." One end of this tube is a special kind of screen. It is here that the picture is formed

How is the picture formed? The television receiver picks up the radio waves sent from the transmitter. The waves are changed back into an electrical current. This current operates another electron gun at the far end of the picture tube. A stream of electrons from the gun sweeps back and forth across the screen. This stream varies just the way the electron stream did in the camera tube. Wherever electrons strike the screen, light is given off. The screen changes electrical energy into light energy. Thus the screen of the picture tube shows up as a pattern of light and dark areas. This forms a picture. It is the same picture that entered the camera tube.

We have taken several minutes to tell how television works. Actually the whole thing happens much faster than we can tell about it. A football game you see on television is really happening at exactly the same moment hundreds or thousands of miles away! Television lets us *see* and *hear* things as they happen. Truly television is one of the wonders of modern communication.

THINKING THINGS OVER.—From smoke signals to television—this is the story of communication. For centuries man's communication was limited to the distance sound waves and light waves would travel in air. But electricity has changed all that. First came the telegraph, using an electric current to operate an electromagnet in a sounder. Then the telephone was developed. The telephone was a great improvement over the telegraph, but both send their messages along wires.

Radio opened up new fields for communication. Radio waves travel through space without wires. Thus sending and receiving stations no longer needed to be connected by wires. Further experiments with radio led to radar, and finally to television. Electricity now gives us *sight* as well as *sound* communication.

What is the result of all these advances in communication? Certainly one result is that we can know what is happening in the world almost at the same time it is happening. When Washington was inaugurated as first president, many people did not know about it until several weeks later. Now when a president is inaugurated, or makes a speech, we can see it and hear it as it takes place.

Radio can bring us voices from the other side of the world. So far television cannot bring us pictures from such great distances. But shall we some day see on our television screens events as they take place in Europe, or Asia, or South America? Only time and the work of scientists can answer that question.

KEY WORDS

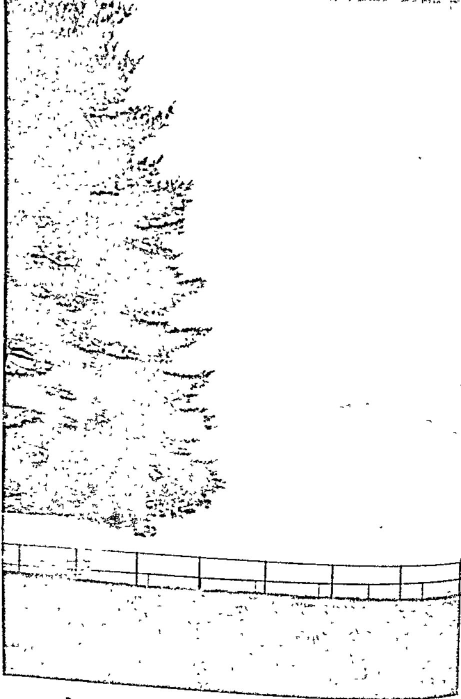
camera tube	radar	teletype
code	radio	television
microphone	sounder	transmitter
"pip"	sound wave	variation (in current)
photoelectric cell	telegraph	vibrations
picture tube	telephone	

Rudner-Pelz

Working Together for Health.—*Personal health is a necessary part of community health. You and the doctor must work together to reach the goal of good personal and community health.*

UNIT IV

Community and Personal Health


NYSPIX—Commerce

Pure, Sparkling Water.—Clean, germ-free water is a must for good health. Supplying such water is a never-ending task for modern communities. This picture illustrates aëration, one step in preparing drinking water for community use.

TOPIC XII

Community Health and Sanitation

DO YOU KNOW—

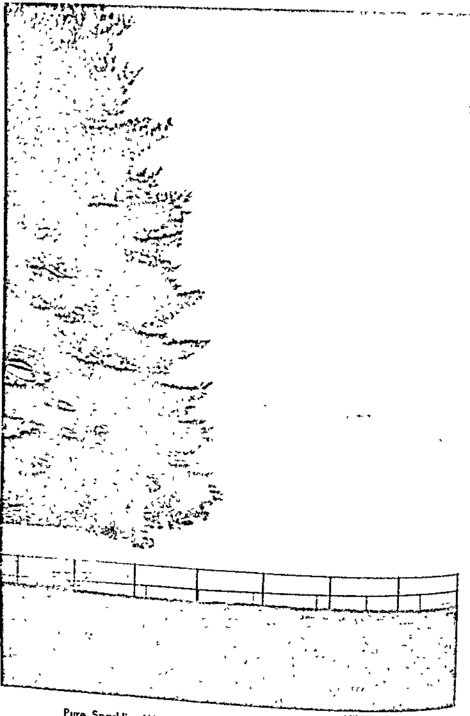
1. Where your drinking water comes from?
2. How your water supply may become polluted?
3. How science is able to prevent disease by proper treatment of drinking water?
4. Why garbage should be protected from flies?
5. Why sewage disposal is a health problem?
6. How to separate a dissolved substance from the water in which it is dissolved?

GENERAL PROBLEM 1

How Is Safe Water Supplied to the Home?

SANITATION, HEALTH, AND WATER.—Good health is the goal of every intelligent person. It is a goal we reach only by hard work. Good health doesn't "just happen." For many, many years scientists and doctors have studied to find out what is needed for healthy lives. Again and again, they have discovered that cleanliness and sanitation are most important in keeping people healthy. Of course other things are important, too. We shall study about some of them later. But over and over again it has been found that the clean sanitary community is the healthful community.

What is involved in being sanitary? Certainly there must be a will to keep clean. And perhaps next in importance is a good supply of safe water. Because water is necessary for life,



AYSPIX—Commerce

Pure, Sparkling Water.—Clean, germ-free water is a must for good health. Supplying such water is a never-ending task for modern communities This picture illustrates *aeration*, one step in preparing drinking water for community use.

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2. How your water supply may become polluted?
3. How science is able to prevent disease by proper treatment of drinking water?
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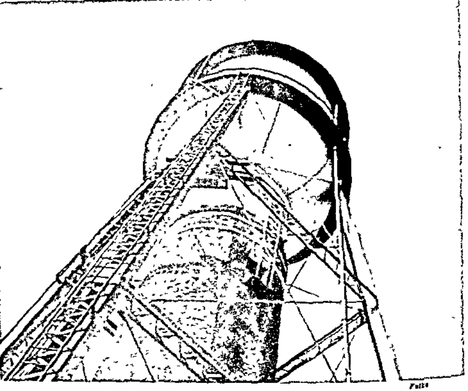


Water Tower.—If there is no high land near the city or town, storage tanks are set atop high towers. Why are towers such as these seen more often in the midwest than along our coasts?

much of a community's health will depend upon its water supply. We should understand the science principles involved in supplying our homes with water.

FROM THE SOURCE TO THE RESERVOIR.—Springs, wells, lakes, and rivers are the common sources of a water supply. Regardless of the source, some system must be provided for bringing the water to the homes where it is to be used. When the water must supply a community of many homes, a storage tank or *reservoir* is used. The science principles involved in bringing water from the source to a storage place are the same regardless of the source of the water. In all possible cases reservoirs are placed higher than the community. This is done so that gravity may be used to force the water through the water mains into the pipes of the houses.

In like manner, the force of gravity can be used to bring water from the source to the reservoir. Again, in order to use gravity, the source must be at a higher altitude than the reservoir. Also, the water must not have to pass over any hill higher than the level of the water at the source.

This system of water supply is called a *gravity system.* When the gravity system cannot be used, a *pumping system* must be installed. The pumping system is more complicated and costs more to operate than the gravity system.

THE GRAVITY SYSTEM.—You know that water runs downhill by gravity. You know also that if the water in a stream is blocked or dammed, the water will fill up and overflow the dam. Water stored in this way exerts a pressure or push to get through the dam. This pressure is due to the force of gravity tending to pull the water down its course to lower levels. The deeper the water the greater the downward pressure. By Experiment 25 you may prove to yourself that water exerts such a pressure. The experiment is important because it will show you how a gravity system works.

Deserted Lake.—There is little danger of this lake's being contaminated. High in the mountains, fed by snow, it would make a good source of water for a small community. Do you think it would be easy to pipe the water from this lake to supply the people in the community below?

Anderson

WHAT HAPPENS.—7. Did water stay in the cylinder at first? What held it in? When a certain depth was reached, did the water push out at the bottom? Why?

8. Did the depth of water required to push out the plate vary with the force exerted by the balance? Did the balance measure the downward pressure?

Make a labeled diagram to illustrate each trial.

CONCLUSION.—Briefly, what did you prove? Give the evidence which you think is proof of your statement.

What was the relation between the downward pressure and depth?

APPLICATION.—Why cannot a person dive more than a few feet into water?

If you were successful with the experiment, you proved that water does exert a downward pressure. The deeper the water, the greater the downward pressure. Downward pressure is caused by gravity and so is called *gravity pressure.*

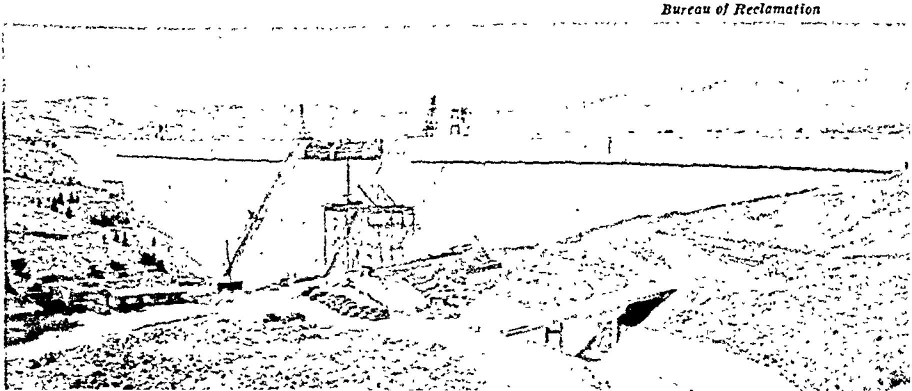
Besides exerting a downward pressure, water exerts a lateral or sidewise pressure also. Experiment 26 will show you how we know this.

FIELD RESEARCH

Examine the plan for a dam. Explain why it provides for stronger construction at the bottom than at the top.

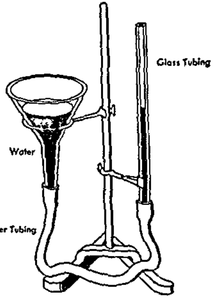
Friant Dam, California.—The concrete structure of this dam is 320 feet high and 3420 feet long. Some construction was going on when the picture was taken. The Friant-Kern Canal is in the foreground.

Bureau of Reclamation



EXPERIMENT 27

Does water seek its own level?



In what ways is this experiment similar to Experiment 26? Look back to Experiment 26, page 321, and figure out what you could add to make it illustrate that water seeks its own level What force is acting on the water in both experiments?

WHAT TO USE.—Funnel, rubber tubing; glass tubing; and a ring stand with clamps.

WHAT TO DO —1. Set up the apparatus as in the drawing so that the water can run from the bottom of the funnel through the rubber tubing into the glass tube held upright.
2 Gradually fill the funnel with water.

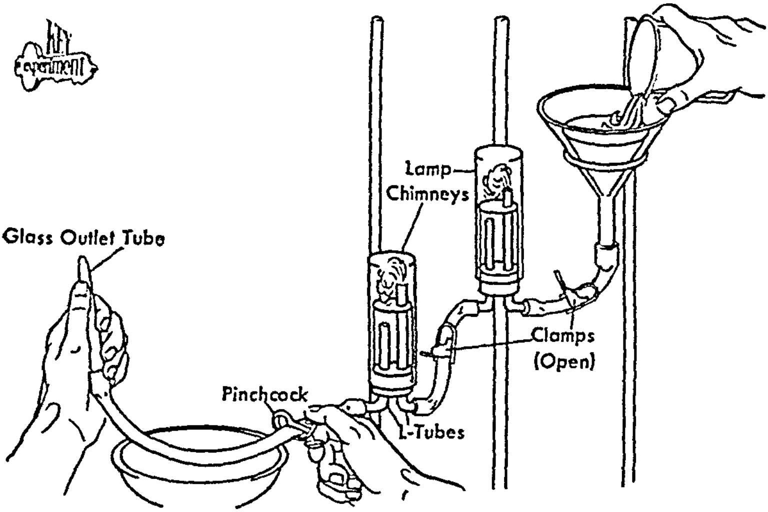
WHAT HAPPENS —1. Does the water run into the glass tube?
2. As you continue to add water to the funnel, how does the height of the top of the water in the tube compare with the top of the water in the funnel?

CONCLUSION.—Consider what you have learned about water pressure and try to explain what you have demonstrated in this experiment.

Now you can understand that a gravity water supply system uses the principles of water pressure. These principles are: water seeks its level because of gravity pressure; and gravity pressure always occurs in water because the force of gravity is always acting.

(KEY) EXPERIMENT 28

How does a model gravity water-supply system work?



Another "Key" Experiment. Why is it important? What difference would it make with the water spurting from the tube at the left, if the container (reservoir) at the right of the hand in the sketch were higher? What force caused the water to flow through the apparatus?

WHAT TO USE.—A large funnel; three pieces of rubber tubing; two straight-sided lamp chimneys with two-hole rubber stoppers or corks to fit; three ring stands and clamps to hold the chimneys; one pinchcock; two clamps; a pointed glass outlet tube drawn to a small opening; and four "L" tubes. One "L" tube should have the long end drawn out to a small opening.

WHAT TO DO.—Study the diagram of an actual gravity system used by a large city and set up a model as shown.

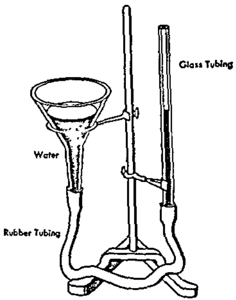
When all is connected and the clamps (representing valves) properly closed, fill the large funnel (representing a lake) with water. Open the "valves" and allow water to flow (1) to the first chimney representing the sedimentation reservoir, (2) then into the city reservoir chimney which contains a fountain (pointed "L" tube), and (3) finally out through the pointed exit tube.

WHAT HAPPENS.—Does the water run (flow) from the funnel (lake) to the sedimentation and then to the city reservoir? Why?

Did the water form a little fountain from the pointed tube in the second chimney (city reservoir)? Why?

EXPERIMENT 27

Does water seek its own level?



In what ways is this experiment similar to Experiment 26? Look back to Experiment 26, page 321, and figure out what you could add to make it illustrate that water seeks its own level. What force is acting on the water in both experiments?

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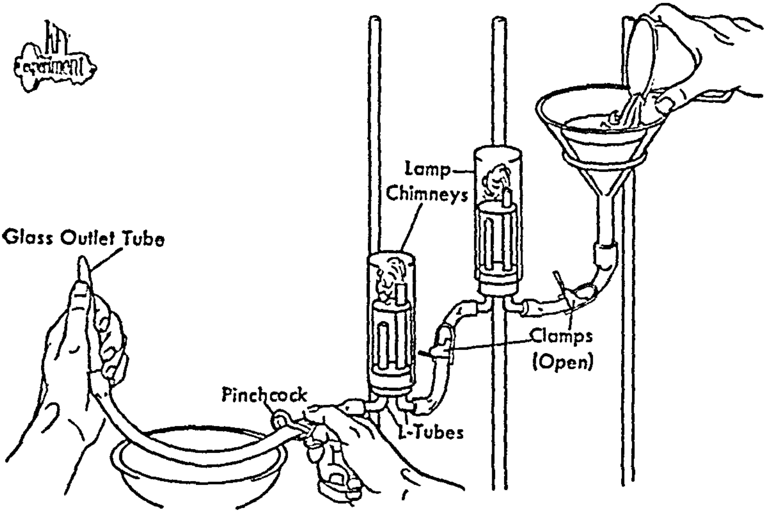

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WHAT HAPPENS.—Does the water run (flow) from the funnel (lake) to the sedimentation and then to the city reservoir? Why?

Did the water form a little fountain from the pointed tube in the second chimney (city reservoir)? Why?

How high does the water spout from the pointed outlet tube? Does it illustrate the principle that water seeks its level?

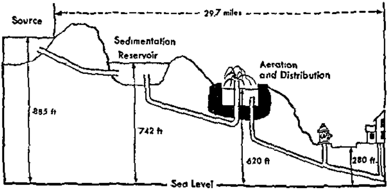
Conclusion.—State how and why gravity causes the water to pass from the lake to the city reservoir.

What causes the water in the conduits to go over hills?

Explain the height to which the water was forced from the outlet tube from the city reservoir.

Application.—What is the result of the difference in altitude between the reservoir and the tall buildings?

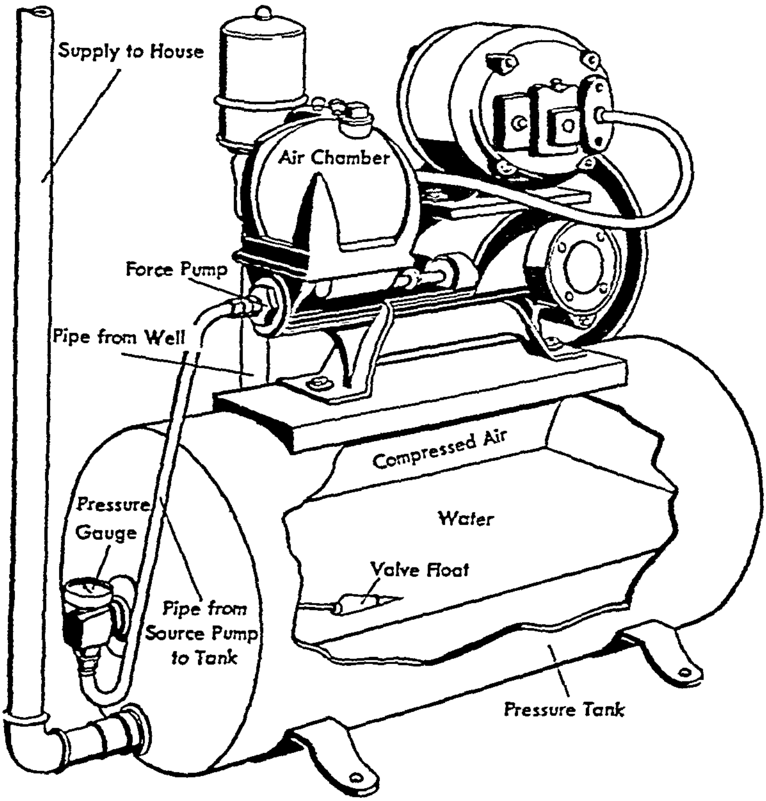
It is well enough to talk about a gravity system, but you will understand it better if you can build a model of such a system. Experiment 28 will help you do this.



A Water Supply System.—This city is fortunate in having a good supply of water about thirty miles away. Some cities must go hundreds of miles for their drinking water. Why would water pumps have to be installed in a 700-foot building in this city?

Pumping System.—Many people, living outside a community water-supply system, install a private pressure system like the one illustrated on page 325. A motor-driven pump forces water from the well into a tank containing air. As the water is forced in at the bottom, the air is compressed into smaller space above the water. The pump continues to force the water until the air pressure becomes 40 lbs. to 50 lbs. per square inch, as required. The motor is then automatically stopped. As the water is withdrawn, the air pressure drops.

When the air pressure drops to about 20 lbs. per square inch, the motor automatically starts. Thus more water is pumped into the tank.



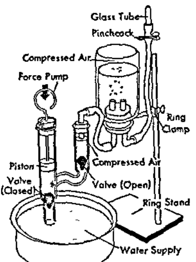
A Pumping System.—The motor in this system automatically turns on and pumps water when the water level in the tank drops. As the water is pumped into the tank, air is compressed. Why? What forces the water up into the supply pipe?

A pipe leads from near the bottom of the tank to other pipes and faucets. When a faucet is opened, water flows out. It is forced through the pipe by the expansion of the compressed air in the top of the tank. In such a system the tank is usually placed in the cellar.

The same plan may be used to supply cistern water for use in the house. This is rain water, collected in a tank or cistern.

EXPERIMENT 29

How can compressed air be used to supply water at higher levels?



What kind of energy is used to work the pump represented in the picture? Where does it come from? What kind of energy is sometimes used on the farm to work the force pump?

When the piston is raised, water comes up around the valve What causes the water to rise in this way? What force causes the water to flow out of the "tank" when the tube is opened? What kind of energy does that represent?

WHAT TO USE —A model force pump; a wide-mouthed bottle (12 oz), a two-hole rubber stopper to fit the bottle, 12" length of wire, two glass "L" tubes and rubber tubing, a pinchcock (faucet); a glass tube drawn to a small opening at one end (nozzle); a dish for water, and a ring stand and large clamp to hold the bottle

WHAT TO DO.—Set up your model as illustrated Place water in the dish (to represent a well or cistern) and operate the apparatus

WHAT HAPPENS —Observe how the air in the bottle (tank) is compressed when you pump and how it expands when you allow water to flow from the nozzle This can be observed by the change in water level in the bottle Where does the air-compressing force come from?

CONCLUSION —In a water system of this kind, what forces the water through the pipes to the faucets?

How does this differ from the water pressure in a gravity system?

What relation do you think exists between the pressure of the air in the tank and the height to which the water will be forced?

APPLICATION.—If you can arrange for it, you will be interested to visit a fire house and find out how the pumper works

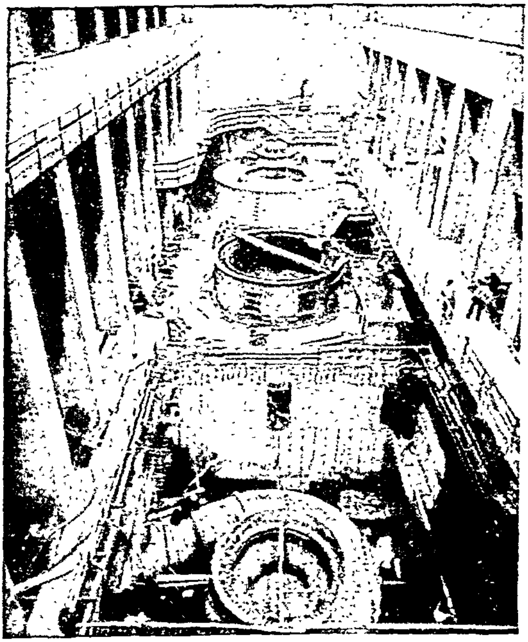
When pumping systems are used to supply whole communities, the water is usually pumped into large tanks or reservoirs. These storage reservoirs are high above the community. They may be some distance from both the pumping station and the homes they supply. Such a water-supply system is really a combination pumping and gravity system. Explain.

Experiment 29 tells you how to set up a model pressure system.

Now that the water is at your door, you are concerned with its distribution to various parts of your house. You are also concerned with its safety from the standpoint of your health. Therefore, the next few sections will help you to discover facts about your home water system. You should also know how the water is made safe for your use, and how you may further protect your supply and thereby your health.

Faucets.—In communities with a common supply system, the water is brought to the house through water mains. It is distributed within the house through small pipes. Faucets are an important part of your water system. They must be simple in construction and easy to repair. The faucet has a valve that may be opened or closed by turning the handle at the top of the post or stem. One type of faucet is in general use. It is made

World's Largest Water Pumps.—Twelve pumps, like the three shown here, will lift water 280 feet from behind Grand Coulee Dam to irrigate 1,000,000 acres in the State of Washington. Each pump delivers over a billion gallons of water a day. In the foreground is a case in which water enters the pump. In the middle, a 65,000 horsepower electric motor is being assembled over another pump. Next is a completed pumping unit.

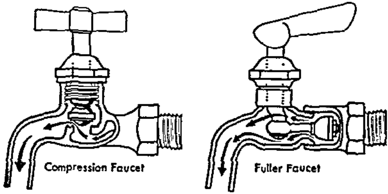


FIELD RESEARCH

If you can get an old water faucet from your plumber, take it apart and compare the parts with those shown in the figure. Put the faucet together and work it.

During your investigation try to discover what makes a faucet leak and how to repair it.

Note: If you try to repair a leaky faucet at home, be sure the water is first turned off in the basement, or below the sink or washbowl where the faucet is located.

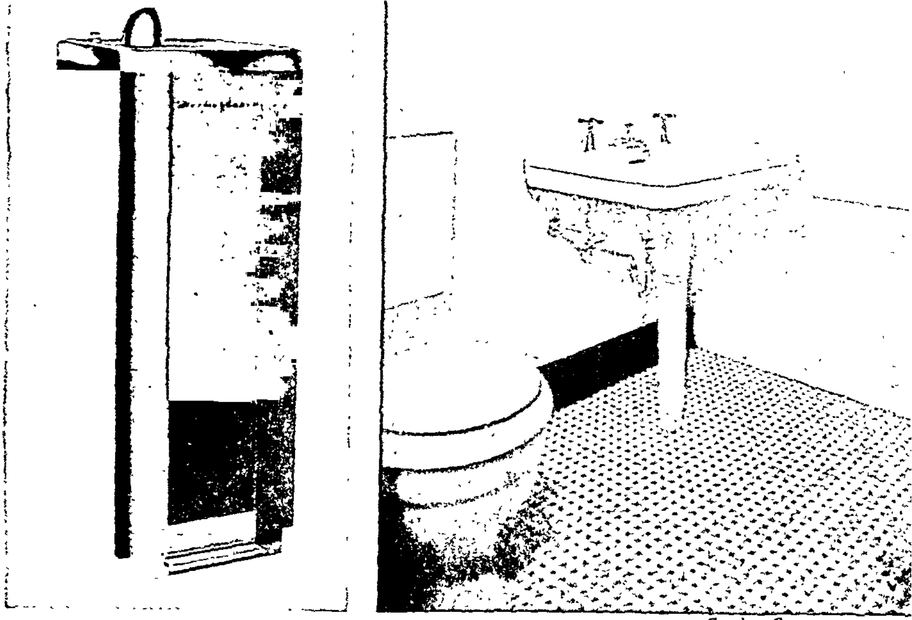


Faucets.—The faucet on the left must be opened and closed by hand. The Fuller faucet is self-closing. No spring is necessary in this faucet. The pressure of the water flowing in the pipe pushes the valve shut unless it is held open.

in various shapes, but a little investigation will disclose that they are all about the same.

Self-Closing Faucets.—In public buildings, including schools, where water is supplied for the convenience of the public, it is wise to use a self-closing faucet. The Fuller faucet, shown above, is self-closing. Some self-closing faucets have a coil spring fastened to the post. When the faucet is opened, the spring is tightened up, and when the handle is released, the spring closes the faucet.

The water in some drinking fountains is turned on by pressing a button near the floor. When the foot is removed from the button, the faucet is shut off. Explain why this is a good sanitary method.



Courtesy Crane

Streamlined Hygiene.—This water fountain (left) was designed for both good looks and sanitation. Water always seems to taste better and colder from such a clean source. Cleanliness is also emphasized in modern American bathrooms (right). Hard surfaces on walls, floor, and fixtures aid in keeping them clean. Explain how.

Faucets for Draining the Water Pipes.—A valve or faucet is placed where the water pipe comes into the water meter from the street main. When this valve is closed, the water is prevented from entering the house. There is another outlet just beyond this valve. It can be opened so that the water in the house pipes will flow out if the faucets in the rest of the house are open. Why must they be open? Can you give several reasons why one might wish to take all the water from the pipes?

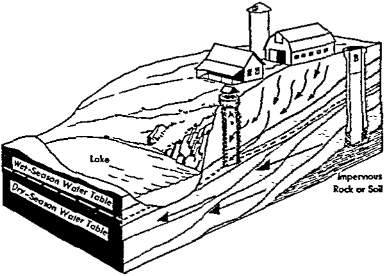
GENERAL PROBLEM 2

How Can Safe Water Be Provided?

Healthful Water in the House.—For home use our water must be clear, free from objectionable odor and taste, and free from dangerous germs. Water from wells or springs which may have been polluted should be boiled for twenty minutes or more This kills all possible disease germs. Likewise, city water should be boiled if there is any possibility of its containing disease germs Boiling for less than twenty minutes may not destroy all disease germs. In the case of the city, the Board of Health will usually notify the people if there is need for any special care Great caution should be taken in the use of water that is not known to be safe.

Water that has been boiled tastes flat when cooled. This is because the dissolved air has been driven out by the heat. Thus it is well to cool the water after boiling and then to shake it with air, some of which will dissolve and improve the taste.

Vacation Dangers.—When a person is out hiking, motoring, or camping, great care should be taken with respect to drinking water. "The Old Oaken Bucket" may bring water from a well in which drainage collects from barns or outhouses. The water, though it may be clear, sparkling, and cold, may



Safe and Unsafe Wells—Which of these wells is unsafe? Why? What important factor should be considered before a well is located on a farm?

contain disease germs. The farmer says, "It's all right to drink; we drink it." True; it is possible that the bodies of the people who drink it may have built up a resistance which protects them against any disease. You may not have that resistance; so beware! When you are not certain of the safety of drinking water, boil it before using it.

Chemical preparations are available that may be carried on a trip to sterilize (kill germs in) water if needed. Iodine, compounds of chlorine, and potassium permanganate are useful, but you need to know just what amounts must be added to the water.

SAFEGUARDING WATER FOR A COMMUNITY.—Let us study a typical city to see how it safeguards its water supply. This city secures most of its water supply from two lakes. One is 395 feet in altitude above the city. The other is 586 feet in altitude above the city. The two lakes together have a surface area of about 2800 acres. Their drainage area, supplying the water, is about 45,000 acres of land, much of which is forested. (What is the relation between forests and water supply?)

Most of the land bordering the lakes is owned by the city. It is possible, therefore, to restrict people from living on the shores. Hence there is no danger of direct contamination by sewage. The lake shores are patrolled and kept clean, free from decaying fish, garbage, and campers' refuse.

Not only is the near-by land protected, but the entire drainage area is inspected continually by health officers. No outhouses or barns are allowed to be located in places where their sewage would drain into streams flowing into the lakes. Thus every precaution is taken to keep the lake waters free from any material that would endanger the health of the people drinking the water.

FIELD RESEARCH

Appoint a committee from your class to investigate thoroughly your own water supply. Build a model to illustrate how it works.

From your local Board of Health you can get information about the number, if any, of cases of typhoid fever during a number of years.

Bringing the Water to the Reservoirs.—Since the lakes are above our typical city, the flow of water takes place by gravity through large conduits Referring to the diagram on page 324, you can trace the course of the water. An intermediate reservoir provides a place where the fine sediment can settle. From this reservoir the water flows by gravity to the distribution reservoirs placed on hills near the city.

The water, after traveling long distances through closed conduits, loses much of its dissolved oxygen. As it comes into the distribution reservoir it is sprayed into the air. This process is called *aëration* It causes the water to dissolve the oxygen of the air, which improves the taste of the water. It also helps to oxidize organic matter, and, to some extent, kills certain kinds of germs that may be in the water.

Purification of Water.—Water may be safe to drink, and yet not be chemically pure. All natural water contains impurities. They may or may not be harmful to man. They may even be beneficial, as, for example, water with certain minerals dissolved in it. The common impurities in water are both *inorganic* (mineral) and *organic* (animal or vegetable) substances. They may be in solution or not in solution. The diagram on the next page shows some of the impurities that may be in water. Follow the arrows to learn the kinds of impurities and how they may be removed.

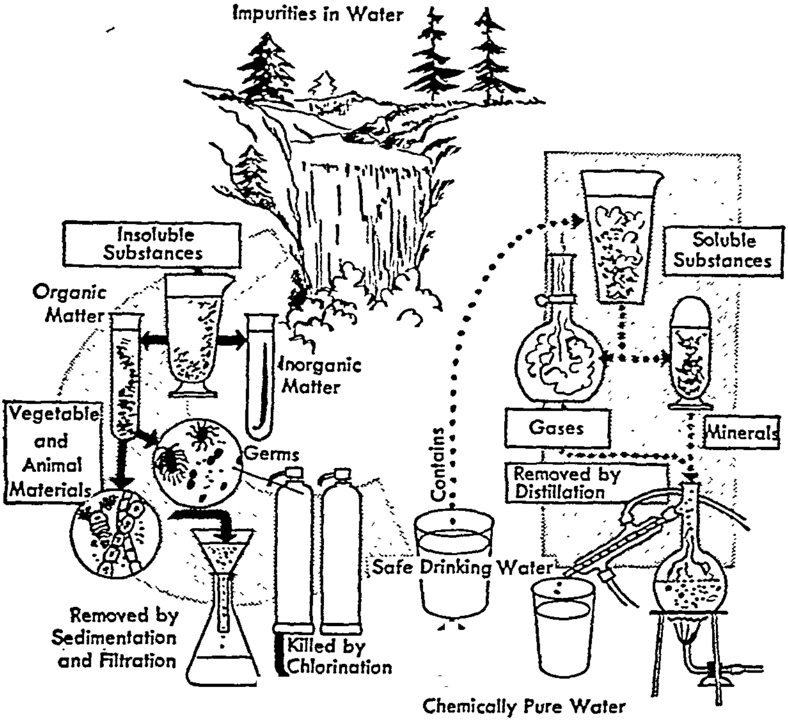
FIELD RESEARCH

Devise and demonstrate a method of separating insoluble impurities from water

The purification of water on a large scale consists of—

(1) *Getting rid of the insoluble material or sediment.*
(2) *Killing any disease germs that may be present.*
(3) *Aërating the water.*

The insoluble material is removed partly by settling. The water is passed slowly through large tanks. This gives time for most of the sediment to settle. You remember that water must

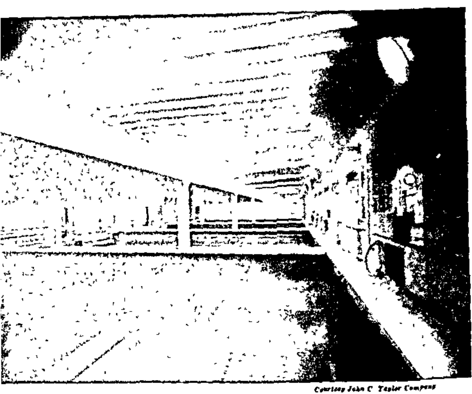


Removing Impurities from Water.—Impurities in water may be either insoluble substances, soluble substances, or both. What are the usual ways of removing insoluble substances from water? How may soluble substances be removed? What is the difference between chemically pure water and water safe for drinking?

be in motion to carry sediment along with it. When water stands still most of the sediment settles to the bottom. Some sediment may be so fine that it takes too long for it to settle. For this reason water from the settling tanks is passed through filters to remove the last traces of sediment.

Bacteria in water may be killed by dissolving a very small amount of chlorine in the water (0.1 to 0.5 parts chlorine to 1,000,000 parts water). The chlorine and the water form an acid which destroys bacteria.

The methods of purification are about the same whether the water is transferred by gravity or by pumping and whether the water comes from a lake or a river.



Courtesy John C Taylor Company

Water Purification.—This water-purification plant at Milwaukee, Wisconsin, is one of the most modern in the world Water in the filter beds shown here is so clear that it reflects the lights and the ceiling with remarkable sharpness. Is clear water always safe water to drink?

WATER IS A SOLVENT.—Water may be safe to drink, and still have much dissolved matter in it. (See diagram on page 333) We know, for example, that water *dissolves* oxygen from the air, and minerals from the soil. Water dissolves many substances. It is also true that water dissolves different amounts of different substances You can prove that substances differ in solubility in water by trying Experiment 30.

WHAT IS A SOLUTION?—*A solution is a clear, even mixture of a substance and water (or any liquid).* The mixture will not change if allowed to stand without evaporating, nor can the dissolved substance be separated from the water by *filtering*. According to our definition, gases and liquids, as well as solids, may be used to form solutions with water. The dissolving liquid is the

Are some substances more soluble in water than others?

You have two new pieces of apparatus in this experiment. What are they?

This is another "Key" Experiment. Why do you think it is so important?

What kind of energy do you use to grind the materials to a fine powder? *It is mechanical energy. How many forms of energy does* this make that you have used? Try to name them.

Why is it best to grind the material to a fine powder? To discover the reason you might try it without grinding.

When the substances are dissolved, *feel* the tube to see if the liquid changed any in temperature.

WHAT TO USE.—Table salt; copper sulfate (blue vitriol); ammonium sulfate; three test tubes; a mortar and pestle; and a beaker of water.

WHAT TO DO.—1. Grind samples of each substance to a fine powder. Put equal amounts of each material (about one half inch in depth) into the three test tubes respectively. Add to each test tube an equal amount of water. Shake the contents of each tube for two minutes, and allow to settle. Observe closely whatever happens.

2. Notice if there is any change in temperature in any of the tubes.

3. Make a labeled diagram of each test tube and contents before and after shaking.

WHAT HAPPENS.—1. Did all of each substance dissolve? Describe.

2. Did the temperature of any of the tubes change? If so, which one changed the most?

CONCLUSION.—Do substances differ in solubility? State the evidence proving your statement.

APPLICATION.—Why does ocean water contain more salt than lime in solution?

solvent; the substance dissolved is the *solute*. Substances vary in their solubility in water. Those which cannot be dissolved are *insoluble*.

FIELD RESEARCH

Test various common substances that you know are practically insoluble in water as follows: Grind each to a fine powder and place a very small amount in half a test tube of water. Shake thoroughly. Does it disappear? If not, heat tube. Does it now apparently dissolve?

Now make a list of ten substances which you think are readily soluble in water. Make your selection, so far as possible, from materials used at home. Test your materials to prove their solubility.

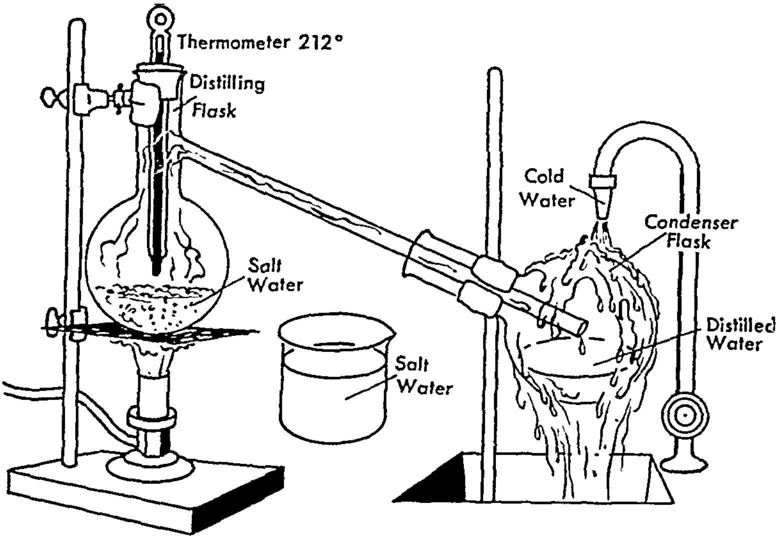
CHEMICALLY PURE WATER.—Chemically pure water is water which contains no dissolved gases or solids of any kind. It is very difficult to obtain absolutely chemically pure water. Water sufficiently pure for most chemical purposes may be obtained by simple *distillation*.

When water containing dissolved substances is boiled, the water portion changes to a gas (steam). The steam escapes. The solid materials of the solution remain. The gaseous water given off is condensed to a liquid again. A pipe surrounded by cold water is usually used to condense the steam into a liquid.

Any two liquids may also be separated by distillation, providing their boiling points are considerably different. For example, alcohol has a boiling point of 172.4° F. and water a boiling point of 212° F. Therefore, it is possible to separate these two liquids by keeping the temperature of the mixture only slightly above 172.4° F. At this temperature the alcohol will change to a gas and escape to the condensing tube. Most of the water will remain. However, a very small amount of

EXPERIMENT 31

How can pure water be obtained from a salt solution?



What process is taking place in the flask at the left? What kind of energy is causing this to happen? Where does that energy come from? How much difference would it make if the thermometer bulb were lowered so that it reached into the water? Try it.

What process is taking place in the flask at the right? What is being removed from the steam? Where does it go? Why does the salt not go over with the steam?

WHAT TO USE.—A distilling flask (250 cc.) with one-hole rubber stopper to fit; thermometer; a condenser flask; cold running water; a beaker; two ring stands and clamps to support the flasks in position; Bunsen burner; and a cupful of salt water made by dissolving two teaspoonfuls of salt in the water.

WHAT TO DO.—1. Set up the apparatus as in the picture, with about a cupful of the salt water solution.

2. Start the cold water running outside the condenser *flask*. If running water is not convenient, cold water can be poured on the condenser flask from a beaker.

3. Heat the solution slowly to boiling and keep it boiling quietly until about half gone.

4 Note the temperature of the steam as the water boils

5 The condensed steam formed in the condenser flask is called the *distillate*. Pour out some of it and test it for color, taste, and odor.

6 Pour out what is left in the distilling flask and test it for color, taste, and odor.

WHAT HAPPENS —3 Did steam form and pass out of the distilling flask?

Could you see the steam change back to liquid in the condensing tube?

How fast did the distilled water drop from the end of the tube into the condenser?

5 Describe the distilled water.

6 What was left in the flask? Describe it.

CONCLUSION —Explain how you prepared the pure water.

APPLICATION.—How does the making of maple sugar depend upon distillation? Why is ocean water salty?

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water will also be driven off with the alcohol since water evaporates to some extent at all temperatures.

To understand thoroughly the process of distillation, try Experiment 31. *The methods of distillation differ slightly with* different substances, but the science principles are the same.

Distilled water is needed by chemists in their work, by people who make up medicines, and by scientists generally for testing purposes Batteries for automobiles should be refilled with distilled water to prolong their life. Ordinarily distilled water is not necessary for drinking.

APPLICATIONS OF DISTILLATION.—The process of distillation has many important applications. *Gasoline* used in automobile engines is a liquid obtained from *crude petroleum* by distillation. At different distilling temperatures different liquids are driven off from the petroleum, such as *gasoline*, *kerosene*, and various grades of *lubricating oils*

Soft coal, although a solid, can also be distilled by heating it in an airtight container. This causes gases such as *coal gas* and *ammonia* to be given off. The solid material left is called *coke*. This kind of distillation is called *destructive distillation*. *Wood alcohol* is obtained by destructive distillation of wood.

How May Sewage Be Disposed of Properly?

WHAT IS SEWAGE?—Waste matters from indoor or outdoor toilets, waste water from basins, bathtubs, and sinks, and street flushing make up what we call *sewage.*

Under ordinary conditions the waste matter from an adult in one year is about 900 pounds, most of which is water. To this must be added the sewage of the streets and about 15,000 gallons of water a year used by each person in a city. Can you see the enormous problem involved in sewage disposal?

IMPORTANCE OF SEWAGE DISPOSAL.—The proper disposal of sewage is next in importance only to the need for safe water. Human beings who are sick may contaminate sewage with disease germs. Therefore, sewage is always a possible source of contagious diseases. Sewage may carry germs that produce typhoid fever, tuberculosis, cholera, dysentery, and diarrhea.

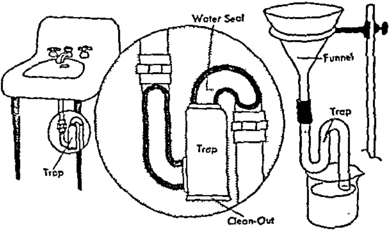
The disposal of sewage begins in the home where the wastes are collected and removed. Sinks, bathtubs, laundry tubs, and toilets are all devices used for carrying sewage away.

FIELD RESEARCH

Investigate water-using devices in your home to find out why they are located as they are. What are they made of? How can they be kept clean and in repair? Make diagrams to illustrate what you find.

SINKS AND TRAPS.—Sinks should be placed so that the plumbing can be readily examined. Metal sinks (enamel or porcelain lined), sinks of special non-rusting metals, and porcelain sinks are most easily cleaned and kept sanitary. Sink waste pipes should be provided with *traps* to make a water seal between the sewer and the opening of the drain.

You have examined the waste pipe running from your sinks, bathtubs, and laundry tubs. Did you discover that the water *runs through a sieve in the bottom of the sink down through a* pipe to the trap? A trap is so constructed that the water runs down one side and fills the other side to the overflow. Then



Traps.—Traps differ in appearance, but are similar in one respect—all have a water seal. What is the purpose of the water seal? Make a trap like the one at the right. Explain why there is always water in this tube.

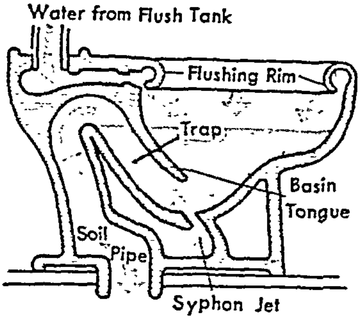
when more water runs into the first part, the second part overflows. Thus there is always water in the trap. This water acts as a wall to prevent gases or odors from coming from sewer pipes into the room. This is the main purpose of the trap.

Some traps are constructed to serve another purpose. They are arranged to catch debris such as matches, toothpicks, tea leaves, chunks of vegetables and hair. The face or bottom of this type of trap may be removed easily in order to clean it out.

FIELD RESEARCH

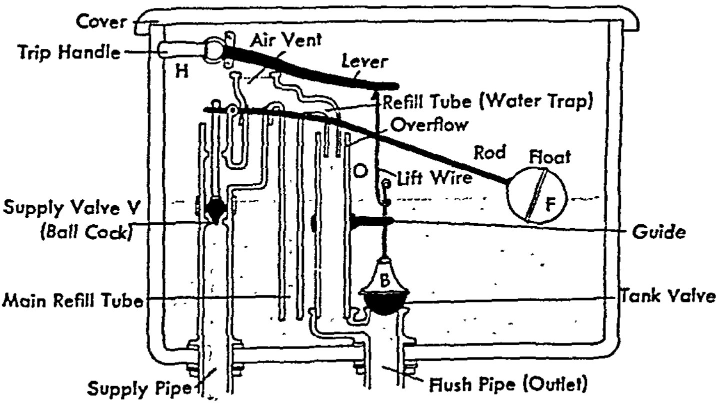
Examine a waste trap provided by the teacher or obtained from a plumber. Note how waste water enters and leaves. Is it so constructed that some water always stands in the trap? Why is that? Make a drawing to show the construction of a trap and explain how it works. Has the trap a "clean-out"? Why is that necessary? Compare the trap with the one pictured in the diagram.

TOILETS.—Toilets are designed to prevent backflow of gases and to provide a rush of water to carry the wastes away. In a *siphon-jet* toilet the water stands on both sides of the tongue and so prevents backflow of gases from soil pipes. This type of toilet is illustrated in the diagram. The water enters the basin and fills it to the rim. When the tank is flushed, some of this water flows down the side and some down through the jet, filling the outlet. The outlet then acts as a siphon (a bent tube for drawing liquids over the side of a container), and all the water is carried out into the soil pipe.



Siphon-Jet Toilet.—This is a picture of a toilet split down the center. A "sectional" diagram like this shows inside parts. Refer to this diagram as you read how the toilet operates. Why is it called a *siphon-jet* toilet?

The construction of an ordinary *float valve flush tank* is shown on this page. If the tank is emptied, the float F sinks to the bottom. This opens the supply valve, allowing water to enter. At the same time the hollow rubber or metal ball B closes the outlet. As the tank fills, the float rises and finally shuts the supply valve at V. The ball B is kept in place by water pressure above it. If now the trip H is pulled, the lever arrangement raises the ball. Once raised and being lighter than water, the ball floats, allowing the water to run out. When the tank is emptied, the ball drops down, closing the outlet again. The float drops and the tank refills. O is the overflow.



Flush Tank.—Refer to this diagram as you read about the flush tank. Then test your knowledge of its operation by explaining the purpose of each part labeled.

Water and Sewage.—Germs that produce human and animal diseases eventually find their way into sewage. Thus it is important to prevent sewage contamination of all streams, ponds, and lakes. It is possible that some person or some animal may need that water for drinking. Fish will not live in water that is badly contaminated with sewage. Sewage contamination decreases the oxygen content of the water. It causes an increase in the growth of water scums and molds, and the destruction of fish.

FIELD RESEARCH

If you know of a stream that is polluted, examine it to find the kinds of plant life and animal life it contains and the kinds it does not contain Try to have the pollution stopped.

Disposal in Rural Districts.—Sometimes dangerous methods of sewage disposal are used in rural districts. The corrections of such methods are indicated by the rules issued by the Department of Agriculture (Farmers Bulletin No. 1227, Sewage and Sewage of Farm Homes).

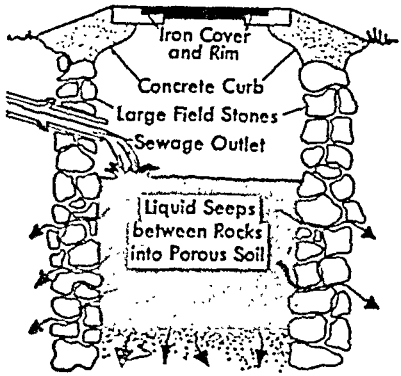
1 Never allow farm sewage or animal wastes even in the tiniest quantity to reach the food or water of man or livestock.

2. Never expose such wastes so that they can be visited by flies or other carriers of disease germs.

3. Never use such wastes to fertilize or irrigate vegetable gardens.

4. Never empty such wastes into a stream, pond, or abandoned well, nor into a gutter, ditch, or tile drainage system which naturally must have an outlet into some water course.

Cesspool.—In districts where sewers have not yet been installed, but where running water is available, *cesspools* are sometimes used As you study the diagram, page 343, you will see that the walls of the cesspool are built up of large loose rocks. These serve as a place for the sewage to collect. The liquid portion seeps away slowly between the rocks. Sometimes a second, or overflow, pool is dug at a lower level than the first. Cesspools need to be cleaned two or three times a year and the refuse burned or buried. At best the cesspool is not a desirable method of sewage disposal. No *provision* is made for the destruction of dangerous germ life nor for the prevention of foul odors. Ultimately the liquid portion finds its way to some stream and so may pollute the water supply.



Cesspool.—Compare the advantages and disadvantages of this cesspool with the septic tank pictured on page 344.

THE DILUTION METHOD.—The *dilution* method of sewage disposal depends upon the principle that if a harmful material is diluted enough, it is not to be feared. Some cities dump their sewage into rapidly flowing rivers or large canals. The sewage is thus greatly diluted. The oxygen dissolved in the water oxidizes some of the organic matter and makes it harmless.

If the stream is overloaded with sewage, complete decomposition of the organic matter does not take place. The stream then becomes a possible menace to health. The stream, at least near the sewage inlet, is unfit for any use by man.

Another dilution method, much practiced, is to carry the sewage by conduits far out into a lake or ocean. With this plan there is always the danger of disease germs being distributed to drinking water intakes, and to bathers. To what extent fish may become infected is a problem not yet answered.

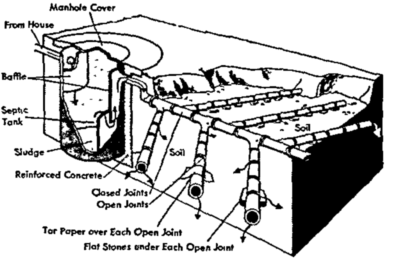
THE CHEMICAL TOILET.—In areas where running water is not available, chemicals may be used to decompose sewage. An iron tank is arranged to hold several gallons of a concentrated solution of *caustic soda* (sodium hydroxide) and a small amount of *copper sulfate* or *copper chloride*. The tank is provided with an outlet near the top. As liquids collect, overflow takes place into a second tank at a lower level.

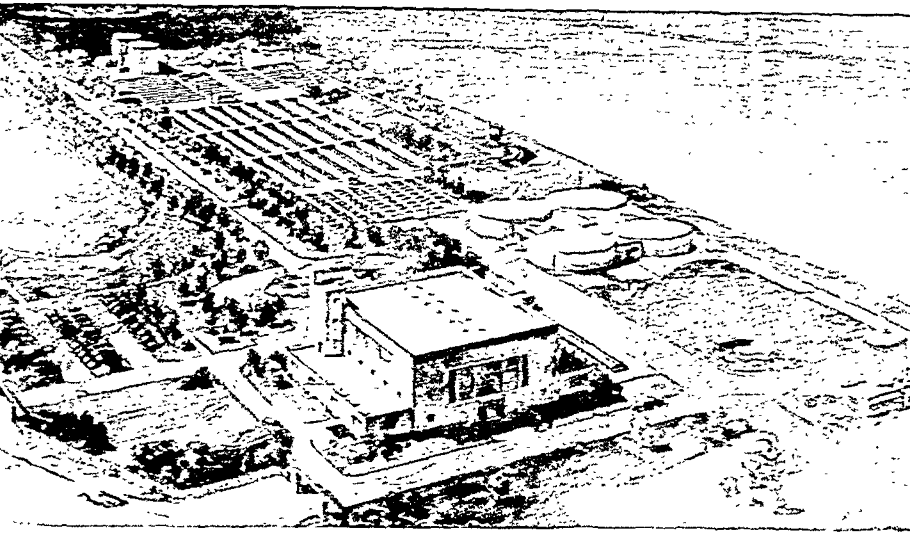
From the second tank the liquids flow through tiles under the ground to an area where it is safe to let the liquids soak into the ground. The solid organic matter of the sewage is acted upon by the caustic soda and changed into harmless liquids. Odors are absorbed by the copper compounds. Occasionally the chemicals must be allowed to run off and a new charge must be added.

THE SEPTIC TANK.—The *septic tank* method depends for its action upon a kind of bacteria that live on organic matter and do not need air. A watertight tank made of steel or concrete is divided into at least two compartments. The sewage flows into the first compartment. Here most of the insoluble organic matter, called *sludge*, settles to the bottom. Excess liquid flows into the second compartment where more sludge is formed, and so on through each succeeding compartment. Finally only a clean and inoffensive liquid is left to flow from the final compartment. This clean and harmless liquid may be allowed to drain into the soil or into bodies of water sufficient to give considerable dilution.

The organic matter of the sewage is acted upon by the bac-

Septic Tank and Filter Bed.—The metal tank at the left is the septic tank. The filter bed is at the right. The septic tank is a good method of sewage disposal. When combined with a filter bed it is even better. Why? How is the sewage made harmless in the septic tank? What is the purpose of the baffles in the tank? Why are the joints of the filter bed left open? Why is a flat stone put under each one? Why are the joints covered with tar paper?





Courtesy Dep't. of Public Works, N.Y.C.

A Sewage Disposal Plant.—This modern plant treats sewage in much the same way as the septic tank. Will the liquid which leaves the basins pollute the nearby river?

teria in the sludge and in a scum that forms at the surface. The bacteria help to break up the offensive material into harmless liquids and gases.

Study the diagram on page 344. Be sure you understand the general principle of a septic tank, and how it is constructed. Its value depends upon the helpful bacteria that decompose the organic wastes.

In general, the principle of the septic tank is used in modern sewage disposal plants for cities. Sometimes the liquid that flows out is sprayed into the air to enable it to dissolve oxygen of the air (aëration). This further purification must, of course, be made before the liquid passes into a stream or lake.

GENERAL PROBLEM 4

How May Garbage and Rubbish Be Disposed of Safely?

What is Garbage?—A ton of garbage will contain about 1460 pounds of water, 80 pounds of grease, and 460 pounds of solids.

FIELD RESEARCH

Watch the garbage pail for a few days to discover what goes into it. Does it contain only unavoidable waste? Or does it contain waste that is the result of carelessness?

Garbage consists of the waste parts of meat and vegetables, unfinished servings, moldy foods, and decayed fruits. All of these materials will decompose (decay) if allowed to stand too long. Offensive odors are then given off and flies are attracted to the garbage.

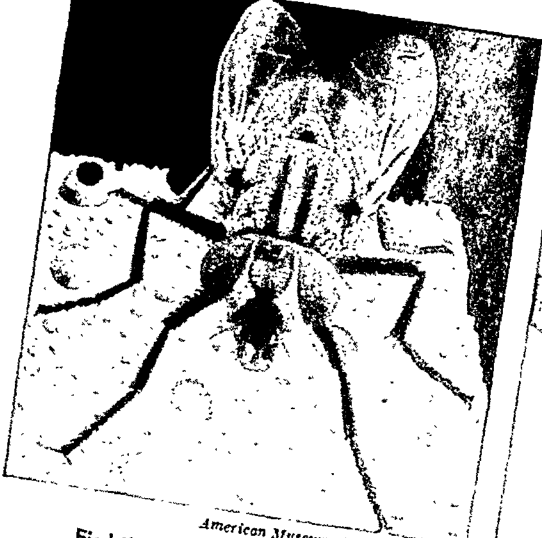
Because decay proceeds faster when the weather is warm, garbage becomes offensive more quickly in summer than in winter Therefore, it should be collected and disposed of more frequently in summer than in winter. In camps and on farms garbage should be disposed of daily. Campers should be sure never to overlook this problem.

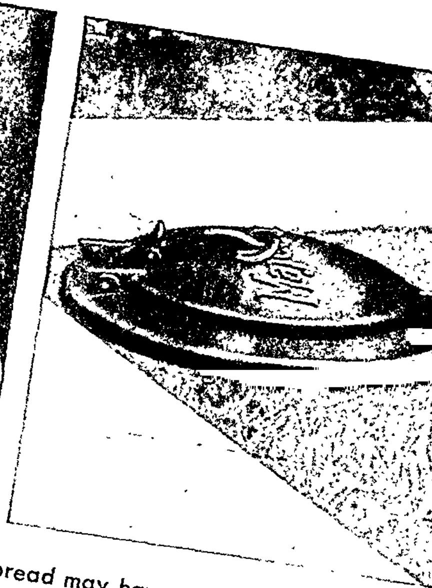
GARBAGE RECEPTACLES.—Garbage pails should be strong, water-tight, and non-rusting. The covers should be fastened so that they cannot be removed by dogs. Frequently the pails are placed in inclosed compartments or in holes in the ground and suitably covered

FIELD RESEARCH

Make a trip to the store and study the different types of garbage pails on sale Determine from the store clerk what he thinks are the advantages of each type. Decide in your own mind which is best and why. Report your findings and conclusions to your class. A drawing will help your description

If garbage pails are left uncovered or are uncovered by dogs, the food material will attract flies. The garbage pail should be cleansed thoroughly each time it is emptied. A good method to use in cleaning it is to sprinkle a little *chloride of lime* into the pail, then add hot water and stir with a cloth on the end of a stick or with a long-handled brush. The chloride of lime will destroy any bacteria, mold, or insect life present. Also, with hot water to melt the grease, the chloride of lime will react





American Museum of Natural History

Fighting the Enemy.—The fly on this bread may have come from a pile of garbage. That is unlikely, however, if household garbage is kept in a container like that on the right. Sunken garbage containers are sanitary for storing garbage temporarily. Covered securely, they do not provide breeding places for flies.

with the grease so that it can be easily rinsed out, leaving the pail "sweet" and clean. (The pail will not rust so rapidly if you will dry it and air it after cleaning. Why?)

HOUSEFLIES AND GARBAGE.—If given the opportunity, flies lay their eggs wherever there is decaying organic matter. Garbage left in a pail, or lying about, forms food that flies like very much. While there to eat, the flies lay their eggs. The eggs hatch into larvae called *maggots*. These change into *pupae* (a resting stage), from which emerge the new-born flies. A new generation of flies arrives every ten or twelve days from early spring to late fall. The female fly lays over 100 eggs at a time. Thus thousands and thousands of flies may be produced from a single pair in just a few weeks' time. Bright sunlight, heat, and exposure to air will usually destroy most fly eggs and larvae.

"SWAT THE FLY."—To combat this dangerous insect, the following rules should be observed:

1. Destroy all flies in the house, especially every fly that enters a sickroom.

2 Eliminate breeding places—decaying matter of all kinds and manure. Most flies are born in unguarded manure piles on farms and in villages.

3. Prevent flies from getting at food in your home and in stores

4 Screen all doors and windows.

5 Remove any possible breeding source at least every ten days to interrupt the generation.

6 *Remember*, when you see a fly in your house it probably came directly from a near-by place of filth. It may carry disease germs on its feet and body.

FIELD RESEARCH

Examine a fly's wing, eye, and foot under a microscope Can you discover how the fly carries filth? Catch some flies and place them under a wire screen with bread and water. Watch them for 15 days to observe their life history.

The common housefly has so often been the carrier of typhoid fever germs that scientists have formed the practice of calling it the typhoid fly. You can make a useful and cheap poison with which to attack this insect. Add a spoonful of formaldehyde to a pint of water. Put in a small amount of sugar to sweeten the solution. Pour it into small dishes and set the dishes wherever you find need for such measures. (CAUTION: *Put the dishes where children cannot reach them.*)

There are also good commercial preparations for spraying. A recent material for destroying flies is the chemical DDT. It is usually sold as a liquid mixed in a light oil, for sprayers It is also available as "DDT bombs" In these "bombs" the DDT is mixed with a liquid which forms a fine mist when released from the "bomb."

Spring and summer are the best times for combating flies. Spray farm manure piles and stables to kill the larvae, and *avoid the conditions which breed flies.*

PRIVATE DISPOSAL OF GARBAGE.—Garbage must be disposed of even where there is no garbage collection. You will agree that the garbage should not be thrown out where it can decompose. Such a practice is a menace to your health or that of your neighbors. It should be buried or burned. The best method of private disposal is burning. Incinerators (ovens for burning garbage and other refuse) are available for installation in homes or for outdoor use. Recently home garbage grinders that fit in the sink drain have been devised. All refuse from the table is finely ground and flushed into the sewer.

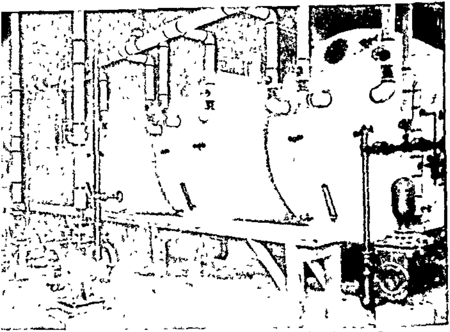
COMMUNITY GARBAGE DISPOSAL.—A large city produces many tons of garbage each day. It must be disposed of in some way that is safe and economical. Two methods have been found most satisfactory. One method is to burn the garbage in a large incinerator. A second method, *garbage reduction*, separates fats from the garbage, and *reduces* the rest to fertilizer. Experiment 32 shows how fats may be dissolved from garbage. The reduction method produces by-products which may be sold. However, the equipment is costly, and many men are needed to operate it. Even though some garbage reduction plants are being replaced by incinerators, it is interesting to study the processes used.

A GARBAGE REDUCTION PLANT.—The garbage is collected regularly in especially constructed trucks. The trucks go to the disposal plant in the center of the city. Here the garbage is first taken into the receiving room for weighing.

It is then lowered into great kettles and covered with a solvent for grease. The kettles are then closed air-tight. Each kettle may hold five tons of garbage. The kettles have a jacket of double bottoms and sides and in this space steam is circulated to heat the garbage. Inside the kettle is a propeller-shaped arm that revolves slowly to keep the garbage and solvent thoroughly mixed. The steam is turned into the hollow wall or jacket and heats the mass to a temperature of about 208° F.

The heat causes water and some solvent to pass off as vapor through outlet pipes. Enough solvent is added so that at the end of about twelve hours of cooking practically all the water of the garbage has been driven off. A quantity of solvent remains which contains the grease and fat in solution. This continued heating also kills any germs in the garbage.

The steam is then cut off from the jacket. The grease solution is drawn out through strainers at the bottom of the kettles.



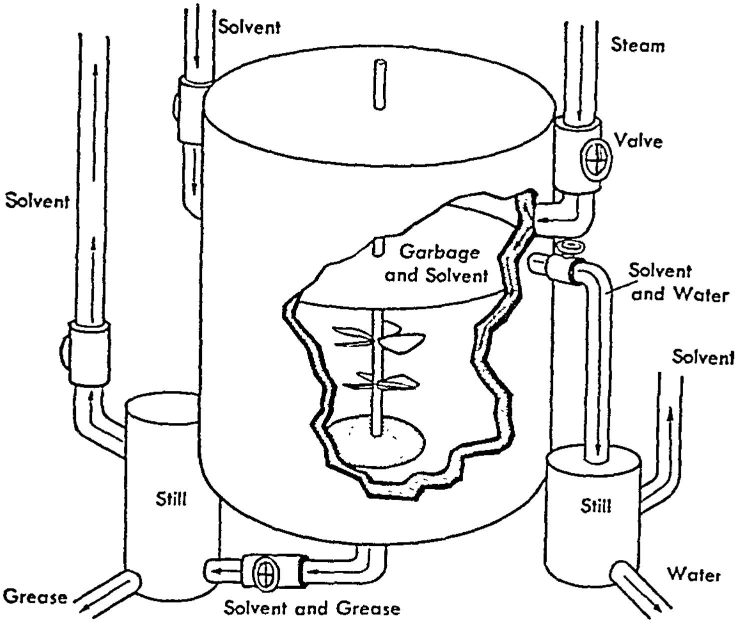
C. O. Bartlett & Snow Company

Distillation.—Inside these tanks is a mixture of grease and a solvent. When the mixture is heated, the solvent is distilled off. The solvent is cooled back to its liquid form and may be used again. This process is used in garbage reduction plants.

More clear solvent is added to the mass in the kettle and stirred and drawn off The process is repeated until no fat or grease is left in the garbage. Any solvent remaining in the mass is driven out by heating for four hours.

The material left in the kettle is dry and lifeless It consists of all material not soluble in the solvent. It may include bones, tin cans, and whatever non-garbage stuff was carelessly put into the garbage pails This dry material is taken out of the kettle and screened. It is passed over a magnetic separator that holds on to all pieces of metal such as tin cans and nails. What gets by the magnet is crushed and then screened again. The final material that goes through the screen is sold as fertilizer.

The solution of fat is pumped into a still and heated The solvent passes off as a vapor through condensing pipes and is used again. The non-volatile grease and fat remain behind. The fat which is left is hot and in the liquid state. It is pumped to fat-storage tanks and sold to glycerine and soap factories.



Garbage Reduction.—This diagram explains some of the principles involved in reducing garbage. The solvent dissolves the grease from the garbage. The stills separate the solvent from the grease and from the water. Where did the water come from? What is the purpose of the steam?

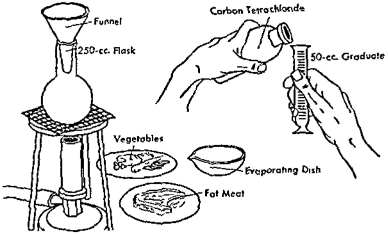
A Modern Rubbish Disposal Plant.—Rubbish consists of about everything a householder throws away other than garbage.

In our modern city nearly 400,000 pounds of rubbish are drawn to the disposal plant daily. On delivery to the plant it is weighed and dumped into a receiving pit. From the pit it is carried to the furnaces where it is burned. The ash is then carted to the dump. The heat from the burning rubbish may be used to generate steam. In our modern city the steam is used in the near-by garbage reduction plant.

Thinking Things Over.—This has been a long topic. It is long because community health and sanitation are so important. Now is the time to think back to some of the things involved in making a community healthy. We have learned that there must be a supply of safe water. In a large community this is a

EXPERIMENT 32

How can fat be dissolved from garbage?



Do you remember what the word solution means? You have made solutions of salt and sugar, and now you will make a solution of fat. Instead of using water, you will use a liquid called carbon tetrachloride. Some carbon tetrachloride will evaporate when it is heated. Be sure you know what the funnel in the flask is for and what process, the opposite of evaporation, results from its use

When evaporating the carbon tetrachloride from the evaporating dish, do not smell of it, because it may be irritating

WHAT TO USE.—A small piece of fat meat (cooked) and pieces of vegetables to represent garbage; a 250 cc. pyrex flask, 50 cc. of carbon tetrachloride, an iron tripod; wire gauze; a Bunsen burner; an evaporating dish, and a funnel.

WHAT TO DO.—1 Grind or chop the foods into small bits Place two tablespoonfuls in the flask and add 50 cc. of the carbon tetrachloride.

2 Set the flask on wire gauze on the tripod or on the hot plate.

Place the funnel over the flask with its stem in the opening of the flask. This is to prevent too great a loss of the carbon tetrachloride which is caused to evaporate by heat

Heat the mixture gently for several minutes

3 After a few minutes, pour off the clear liquid into the evaporating dish and place it on the wire gauze and tripod in place of the flask. Heat carefully until the solvent appears to be gone. *Do not heat the residue hot enough to burn it*

Allow the contents to cool and examine them.

WHAT HAPPENS.—1, 2. Did you observe solution of the fat taking place?

3. Was there a fatty residue left in the evaporating dish? Tell why you think it is fat. Where did it come from?

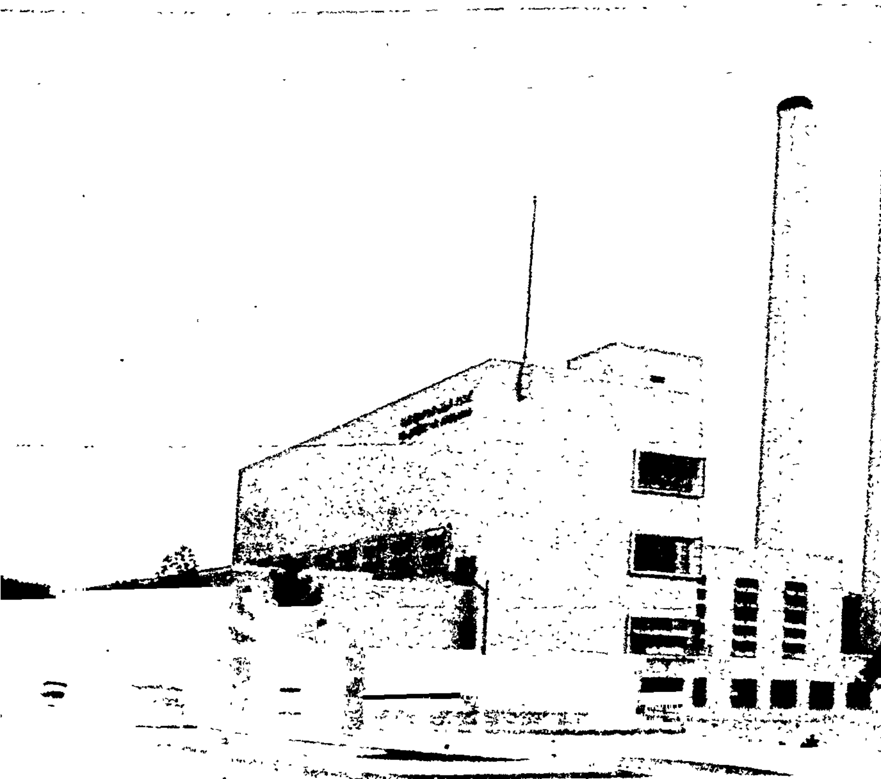
CONCLUSION.—How can fat be dissolved from garbage?

APPLICATION.—How can a grease stain be removed from a fabric?

major problem. It may mean bringing water hundreds of miles through conduits. Then the harmful impurities must be removed from the water. Do you remember how this is done? Do you remember how a gravity water supply system works? And a pumping system?

A Modern Incinerator.—Huge furnaces in this modern plant burn tons of garbage and rubbish each day. The chimneys carry the gases high into the air, where they will not interfere with the air we breathe. Why are incinerators used more often than garbage reduction plants?

Courtesy Dep't. of Public Works, N.Y.C.



But a healthful community must also have good methods of disposing of sewage and garbage. We know that sewage is always dangerous It usually contains germs which cause diseases The community must get rid of garbage because garbage is a good place for flies to breed. Flies, we know, are "Public Enemy No 1" They carry filth and dirt wherever they go Thus modern communities burn their garbage or reduce it Either method is good.

Of course, community health is just one part of the big problem of health Personal health is another part. And this is the subject of our next topic.

Key Words

aëration	distillation	insoluble	sewage
bacteria	fat	maggot	sludge
caustic soda	faucet	organic	soluble
cesspool	garbage	pollute	solute
chlorine	gravity	pupae	solution
conduit	housefly	pure	trap
dilution	incinerator	reservoir	water pressure
dissolve	impurities	septic tank	

Key Statements

1 Water for a community should be abundant, safeguarded at the source, and purified for drinking before distribution

2 Water may be safe for drinking and yet not be chemically pure.

3 Water may be crystal clear and cold and yet be unsafe to drink.

4. Lakes and rivers are common sources of water for community uses

5 Water may be brought by gravity to a community from sources higher than the community From sources lower than the community, water must be pumped into storage tanks or reservoirs for distribution

6. Water exerts a downward (gravity) pressure due to its weight.

7. Water pressure increases with its depth.

8 Water flows downhill, or seeks its level, because of gravity.

9 In small systems, compressed air in a tank in the basement can be used to force water through the pipes of a house.

10. The water sources of a community water supply must be protected against contamination

11. The purification of water for drinking purposes includes separation of insoluble sediment and killing of disease germs.

12. Chemically pure water may be prepared by distillation.

13. Substances vary in their solubility in water.

14. Sewage consists of wastes from sinks, toilets, and streets, mixed with or dissolved in water.

15. Disease germs may be present in sewage; hence its proper disposal is an important factor in the health of a community.

16. Untreated sewage should not be allowed to pollute streams.

17. Flies should be prevented from access to farm and home wastes of all kinds.

18. The presence of flies often indicates the location of filth.

19. A cesspool is a drainage tank for sewage.

20. The chemical toilet depends for its efficiency upon the dissolving action of alkali.

21. The septic tank sewage disposal plant depends upon bacterial action to render the sewage harmless and inoffensive.

22. Garbage consists chiefly of food wastes. It should be protected from flies and should be disposed of before it decomposes.

23. Proper disposal of garbage involves frequent collections and inoffensive disposal plants.

24. The principle of the septic tank is the best to follow in the disposal of sewage.

Thought Questions

1. How can you prove that water dissolves oxygen?

2. How can you prove whether a sample of water contains anything in solution?

3. What is meant by *condensation*?

4. What is meant by *pure water*?

5. Why may water for drinking need to be purified?

6. Is water safe for drinking necessarily chemically pure water?

7. What care should be taken in locating a well on a farm?

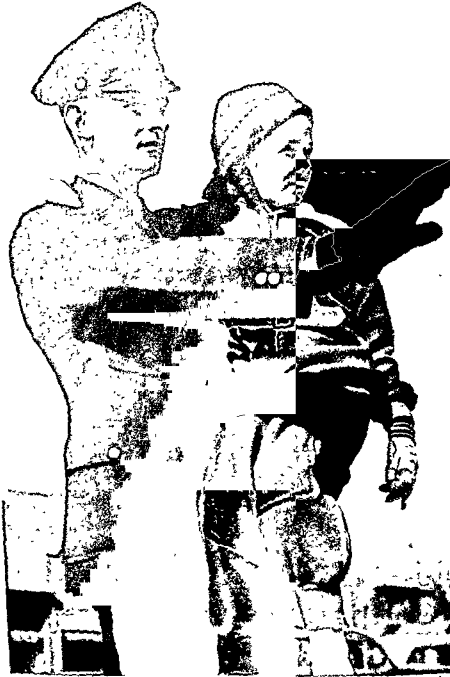
8. Why are wells a possible source of danger in villages that do not have a sewage system?

9. Why are dams constructed with thicker walls at the bottom than near the top?

10. Why will not faucet filters take germs from water if germs are present?

11. Why should drinking water of unknown source be boiled?

12. What evidences can you give from observations of nature that water exerts a gravity pressure?



National Safety Council

Safety is Everyone's Business.—The traffic officer on the corner helps prevent accidents, but he cannot do the job alone. Safety is our job, too, at home, at school, and at play.

TOPIC XIII

Personal Health and Safety

DO YOU KNOW—

1. What makes water hard?
2. How soap and water help to keep you healthy?
3. Why the milk supply presents special health problems?
4. What the "wonder drugs" are?
5. How to protect your eyes and ears?
6. How to play safely?

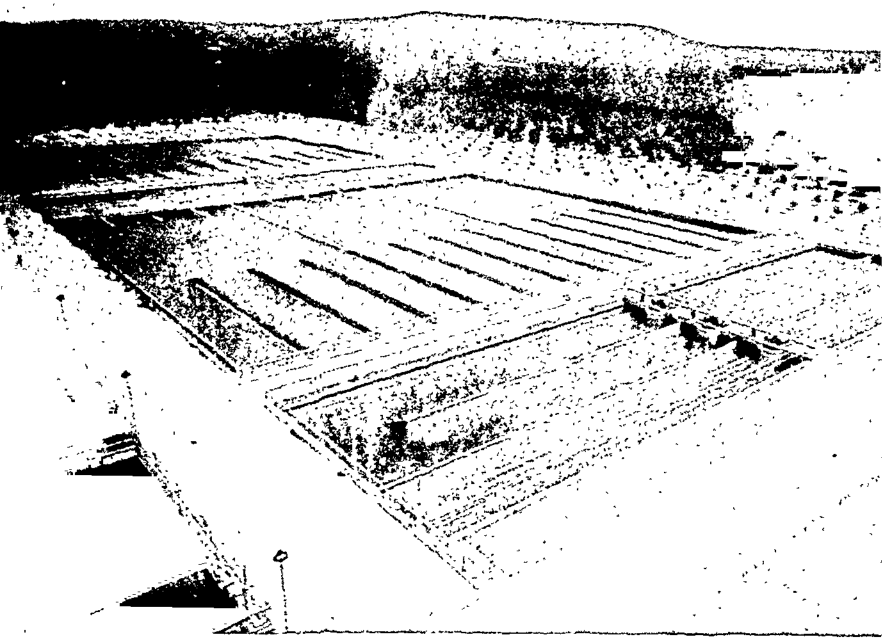
GENERAL PROBLEM 1

How Do Soap and Water Aid Cleansing?

HARD AND SOFT WATER.—One of the important uses of water in the home, restaurants, factories, and public buildings is as a cleansing agent. Certain minerals in the water supply affect its usefulness for cleansing purposes. The term "hard water" indicates that some water contains lime materials in solution. Water that does not have dissolved lime materials is called "soft water."

We know that wells, springs, and lakes are fed with water that has passed through soil and rock layers. If the rocks and soil through which the water passes contain lime materials, the water will dissolve some of them and become hard.

Earlier in your study of science you learned that the air contains *carbon dioxide*. This carbon dioxide gas of the air is slightly soluble in water. It forms *carbonic acid* with the water. (Carbon dioxide plus water gives carbonic acid.)



Bob Landry

Making Hard Water Soft.—This is one of the largest water-softening plants in the world. It can soften 200 million gallons of water a day. *What are the advantages of soft water? What are the advantages of softening water before it is distributed to homes?*

Experiment 33 proves that temporary hard water can be softened by boiling. You have read that boiling does not, however, soften permanent hardness due to calcium and magnesium sulfates. However, permanent hard water can be softened with washing soda. This is illustrated by Experiment 34.

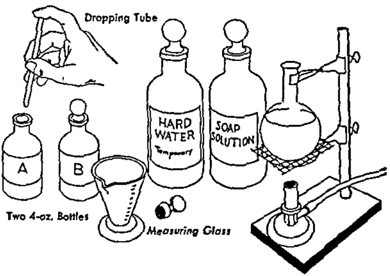
Certain substances like washing soda, borax, or trisodium phosphate *unite chemically with the minerals which cause hardness.* Insoluble forms of sulfates and carbonates are produced. When insoluble, the minerals no longer affect the water. Thus the water is soft.

Experiment 34 teaches that hard water requires more soap for proper suds than soft water. Soap costs money. So hard water is expensive to use for cleaning purposes.

Water Softeners.—In dishwashing machines, laundries, and heating plants where soft water is an advantage, special water-softening equipment is used that works continuously.

EXPERIMENT 33

Can temporary hard water be softened by boiling?



Straight thinking is needed in this experiment; so make sure you know just what your problem is and what you are to do. The size of the bottles is not important so long as they are not too large.

WHAT TO USE.—Water with calcium bicarbonate in solution (this is called "temporary hard" water), a dilute soap solution; two 4-oz. bottles with glass stoppers or corks, a dropping tube (made by melting a glass tube and drawing one end to a small opening, should be about 8" long), a flask, supports, a measuring glass, and a Bunsen burner to boil some of the "hard" water.

WHAT TO DO.—1. Boil a portion of the diluted "hard" water for several minutes and then cool it to room temperature.

2. Put 2 oz. of boiled water into the bottle labeled *A* and 2 oz. of unboiled hard water into the bottle labeled *B*.

3. Now add the soap solution, drop by drop, counting each drop, to the water that has not been boiled (*B*), shaking the water between drops. Keep adding soap until a fine permanent suds results (a suds that will last for one minute).

4. Repeat the soap test using the boiled water (*A*).

WHAT HAPPENS.—1. Did boiling the hard water cause any noticeable change in its appearance? Describe.

3. How many drops of soap did you use for the unboiled water?

4. How many drops of soap did you use for the boiled water?

Which was the softer water; that is, which sample required the fewest drops of soap to make a good foam or suds?

CONCLUSION.—Did boiling the water soften it? How?

APPLICATION.—Why does some water leave more of a deposit in automobile radiators or teakettles than water from other sources?

Note.—Temporary hard water can be made by passing CO_2 through limewater until the precipitate that forms redissolves. By this process you have made a solution of calcium bicarbonate. For use, dilute this solution with ten times its volume with distilled water or rain water.

Save a portion of the water with calcium bicarbonate in solution for Experiment 34.

The hard water passes over certain chemicals which remove the minerals causing hardness. Every so often the flow of the water is stopped. Salt water is passed through the chemicals. The salt water removes the minerals from the chemicals and is washed away. Then the chemicals may be used for softening more hard water.

Soap and water are the most common aids to cleansing. We have learned that the hardness of the water affects the amount of soap needed. Now we shall learn about soap. What is soap? How is it made? How does it work?

VARIETIES OF SOAP.—There are many varieties of soap. Some of them, according to advertisements, will do very special things. We should remember, however, that soaps have just one purpose. They help to clean.

A cake of soap, although it appears to be dry, contains a certain amount of water. A cake of soap that you buy may be from 15 per cent to 50 per cent water.

LABORATORY RESEARCH

Cut a few thin slices of soap from the center of a cake. Weigh them and dry in an oven at 220° F. for one hour. Weigh the residue. Calculate the percentage of loss of weight as water. You can compare one soap with another by this method.

EXPERIMENT 33

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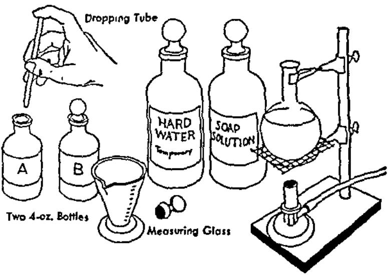

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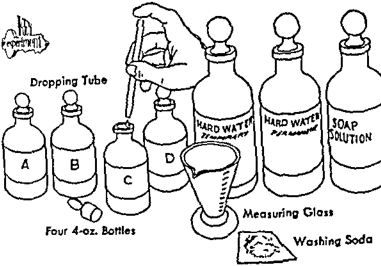
(KEY) EXPERIMENT 34

Can hard water be softened by the use of washing soda?



It will be a good additional problem for some of you to try to explain why a solution will not drop out of a dropping tube when the finger is kept tight against the top end.

WHAT TO USE.—A sample of temporary hard water (saved from Experiment 33), a sample of permanent hard water (made by shaking some distilled water or rain water with a small amount of calcium sulfate); a dilute soap solution as used in Experiment 33; four 4-oz bottles with glass stoppers or corks, a dilute solution of washing soda (one teaspoonful to one pint of water); measuring glass, and a dropping tube.

WHAT TO DO.—1 Label the bottles *A*, *B*, *C*, and *D*.

2 In *A* place two ounces of the temporary hard water; in *B* place two ounces of the temporary hard water and one half teaspoonful of the washing soda solution, and shake.

3 Using the soap solution as in Experiment 33, find the number of drops required to make a permanent suds in *A* and in *B*. Record your data

4 Repeat as above, using permanent hard water in *C* and permanent hard water plus one half teaspoonful of the washing soda solution in *D*. Record the number of drops of soap solution used in *C* and in *D*

WHAT HAPPENS.—3. How many drops of soap solution did you use in *A*? In *B*?

4. How many drops of soap solution did you use in *C*? In *D*?

CONCLUSION.—Can temporary hard water be softened by the use of washing soda? Explain.

Can permanent hard water be softened by the use of washing soda? Explain.

Note.—You may repeat the experiment using borax solution, trisodium phosphate, or any commercial water softener instead of the washing soda.

APPLICATION.—Do you think the use of water-softening substances would save soap? Why?

RAW MATERIALS FOR MAKING SOAP.—The materials used in the manufacture of any product are called raw materials. These raw materials must be worked on or changed or combined with something else before a finished product is obtained.

Soaps are made by the action of an alkali on a fat or oil. Fat or oil and the alkali are the raw materials from which soap is made. Before investigating the manufacture of soap we shall study briefly the raw materials used in its manufacture.

FATS AND OILS.—Oils and melted fats make a grease spot on paper or cloth. Therefore, a piece of white paper will serve as a ready test for fats and oils.

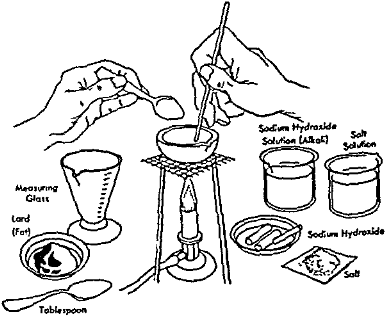
Animal fats are usually solid substances at ordinary temperatures, but they are easily melted. Butter fat has such a low melting temperature that it is melted by body heat. This makes it especially valuable as a food. The fats obtained from seeds or other parts of plants are usually liquid at ordinary temperatures; thus they are usually called oils.

FIELD RESEARCH

Test small samples of fats and oils as follows: Drop or rub a little oil or fat (warmed, if necessary) on a piece of white paper. Hold the paper to the light. A "grease spot" will appear lighter than the paper. If held so that light is reflected from the paper, the spot will appear darker than the paper. This is because the greased or oiled paper is more transparent to light than the paper itself.

EXPERIMENT 35

How can soap be made?



Instead of a porcelain evaporating dish you may use a small granite dish. Do not use an aluminum dish, because aluminum dissolves in an alkali solution.

WHAT TO USE —Lard (fat); a 40% alkali solution (sodium hydroxide dissolved in water); a porcelain evaporating dish; a glass stirring rod; a tablespoon; a teaspoon, an iron tripod or other support; wire gauze; a beaker; a Bunsen burner; and a measuring glass.

WHAT TO DO —1. Set up the apparatus as in the drawing.

2 Put two level tablespoonfuls of lard (fat) into the evaporating dish.

3 Heat the lard gently until it melts and, while heating, add slowly one teaspoonful of the alkali solution, stirring constantly.

4. Heat gently, stirring constantly, until there is no evidence of oily particles and until a soap mass forms. Then add 3 ounces of water while heating and stirring.

5. Pour the mixture into the beaker and add one teaspoonful of salt solution (equal parts salt and water), heating gently and stirring.

6. Set the beaker and contents aside until the next day. Then take off the "cake" of soap formed at the top. Examine the liquid left in the beaker

7. Test the soap to find if it will form a lather.

WHAT HAPPENS.—3. Describe what happened when the alkali was added to the hot melted lard and stirred.

4. What happened when the water was added?

5. What happened when the salt solution was added?

6. Did a solid cake of soap form in the beaker?

7. Did it form a good lather? Was there evidence, in using the soap, of excess (extra) lard (fat) or excess alkali? If so, what was the trouble with your process?

Note.—The liquid left in the beaker consisted of water, excess alkali, salt, and glycerine.

CONCLUSION.—State briefly a method of making soap. Do you think that other fats or oils could be used instead of lard? Try it.

APPLICATION.—Place a little oil in some water. Add a small amount of washing soda and shake. If suds appear, explain.

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mixed. The fat and the alkali gradually unite chemically to form soap and *glycerine*. Salt is now added which causes the soap to separate from the liquids which contain glycerine, excess alkali, and the added salt. The soap comes to the top of the kettle. The liquid is removed and pure glycerine is obtained from it by distillation.

The crude soap thus made is then treated with a more concentrated solution of the alkali. Water is added and the mixture boiled until it is fine-grained in appearance. The mixture is again "salted" and allowed to stand for several days. Once more the soap rises to the top and the liquid below is drawn off.

The next step in the process is the adding of perfume, borax, washing soda, or filler to the melted soap. The soap is then run into boxes and allowed to harden. After it has hardened sufficiently, the soap is cut into small cakes or bars. These are then pressed into special shapes with trade names stamped on. After drying they are wrapped and boxed ready for the consumer.

Not only is the manufacture of modern soap a complicated process, but also a process that requires great accuracy in measurement. Chemists constantly test the raw materials and the intermediate and final product to be sure it is up to standards set by the manufacturer.

Courtesy Procter & Gamble

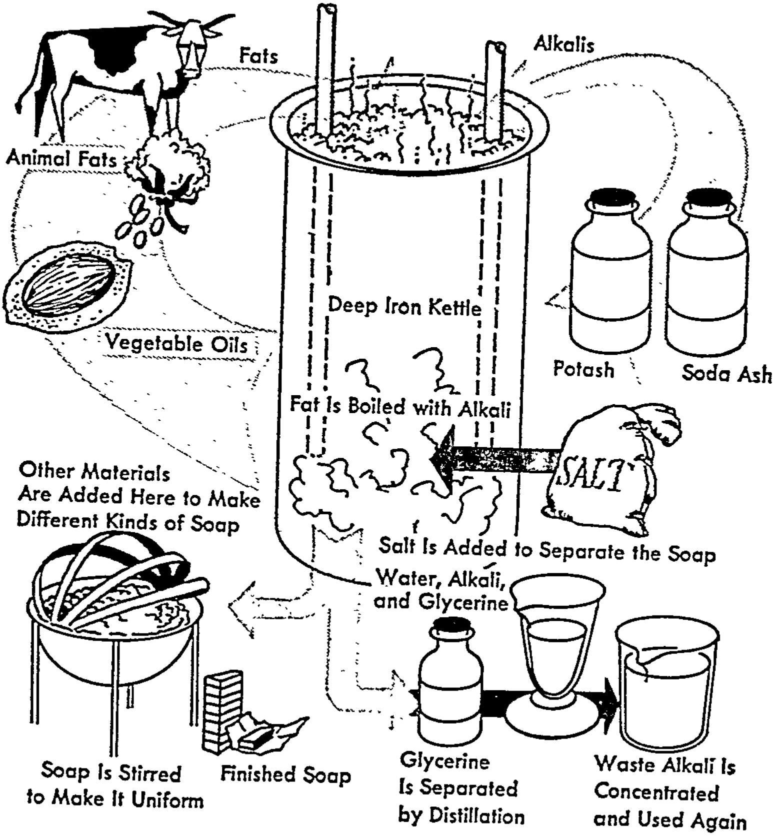
Soap Making —This boiling, erupting liquid is a beginning step in the manufacture of soap. Here fats, oils, and alkali are being boiled in a giant kettle. Now you continue the story, using the diagram on the opposite page.

Cream, butter, lard, and suet are *animal* fats Olive oil, peanut oil, cottonseed oil, and linseed oil are examples of *vegetable* fats. Both animal and vegetable fats or oils are used in making soaps.

ALKALIES.—The chemist classifies many substances as *acid*, *alkaline*, or *neutral* substances. *Acids* have a sour taste. They turn blue *litmus* paper pink.

An *alkaline* substance, in solution, has a bitter taste. When rubbed upon the fingers, it has a slippery feeling. It changes the color of litmus paper from pink to blue. These are ways to test for alkaline substances. Many alkaline substances are known to the chemist. Two, *potassium hydroxide* and *sodium hydroxide*, are commonly used in making soap.

Neutral substances do not change the color of litmus. Pure water and solutions of *salt*, *glycerine*, and *sugar* are examples of neutral substances.



Making Soap.—Follow the arrows in this diagram. What is the finished product? Does it make any difference which alkali is used in making soap? What is the important by-product made? What is it used for? How can the waste alkali be concentrated?

Manufacture of Soap.—The modern methods of making soap are very complicated. The science principles, however, as shown in Experiment 35, are easily understood.

The accompanying drawing illustrates the steps and materials involved in soap-making.

Boiled laundry soaps and boiled toilet soaps are made by placing the melted fat or oil into a huge kettle. The proper amount of the alkali solution is added and mixed with the melted fat or oil. Steam is then passed into the mixture. This heats the mixture and at the same time keeps it thoroughly


Courtesy Procter & Gamble

Ribbons of Soap.—Soap may be made in many different shapes and sizes. These ribbons are the first step in making soap flakes. Do soap flakes have any special advantages?

SPECIAL SOAPS.—Liquid soaps are usually mixtures of potash and soda soaps dissolved in water and containing small amounts of glycerine. Liquid soaps used for toilet purposes are frequently made chiefly from coconut oil. Floating soaps are prepared by stirring melted soap in such a manner as to leave the soap full of very tiny air bubbles. The air bubbles act like little balloons which float the soap in the water.

Mottled soaps are made by adding coloring substances. Transparent soaps are made by dissolving hard soap in alcohol. Then, after removing any foreign material, the alcohol is distilled off. The transparent, jelly-like mass left is allowed to dry in molds of the desired shape. Soaps for shaving, shampooing, use on the skin, and in tooth powders are made with special care to avoid soapy odors, excess alkali or oil, and taste. They must lather freely.

Some soaps are called *medicated soaps* to indicate that they have some drugs in them. It is better to use drugs only on the advice of a physician, either on the skin or in the body. Do not use medicated soaps unless advised to do so by a physician. They are expensive and probably of no more use than a good quality of toilet soap.

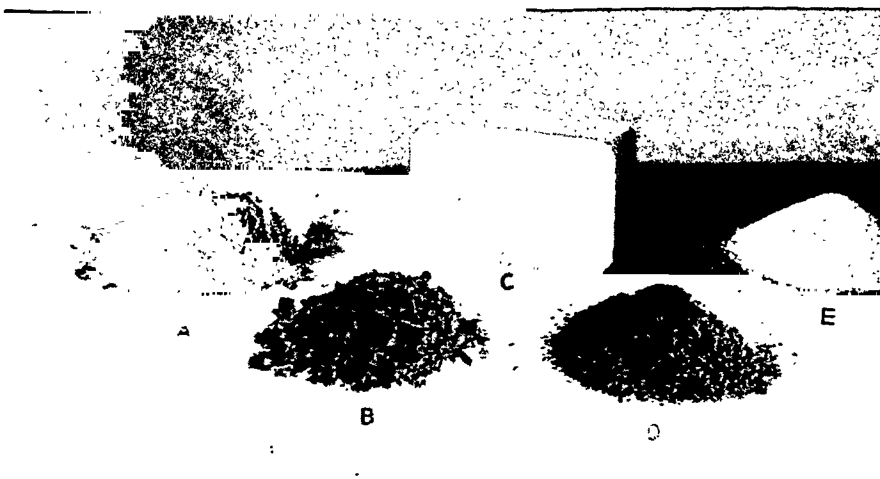
Scouring powders are soap powders to which small amounts of scouring material are added. Such scouring powders are useful, provided the scouring material does not scratch the surfaces that are scoured. If the polished surface of a utensil becomes covered with fine scratches, it is harder to clean.

Soaps are sometimes "loaded" with cheap substances that make the cake larger and heavier. Such substances are called *fillers* and may or may not have a value. For example, a soap for use with hard water may have some washing soda added to help soften the water. It is probably cheaper to buy washing soda and ordinary soap separately and then add the washing soda to the water as needed.

Rosin is sometimes added to soap and is generally indicated by its yellow color. Rosin is a filler that has doubtful use in a soap. It may help in the formation of a suds or lather. Another chemical called *water glass* is sometimes added to soap. It is a filler that has no important use.

We cannot give all the details of the many kinds of soap. The thing to remember is that any claims as to why one soap is better than another should be considered carefully. Evidence should always be required to prove the claims. Do not be swayed by unsupported claims.

Special Soaps for Special Purposes.—A is a scouring powder. B is soap flakes. C is bar soap. D is beaded soap. E is powdered soap. How do these forms of soap differ from each other? Is there a "best" form? Explain.



Making Suds.—Both beakers contained hard water. A *detergent* was added to the beaker on the left. Soap was added to the beaker on the right. Does this picture help you understand why detergents are often used in regions where the water is hard?

SOAP SUBSTITUTES.—Some substances may be used with water for cleansing even though they are not soaps. When dissolved in water, washing soda will help loosen dirt and grease. Trisodium phosphate may also be used for the same purposes

In recent years many new soap substitutes have appeared. Most of them are sold for use in home washing machines or for dishwashing. They are sold under a variety of short trade names. These substances are called *detergents*. Dishes washed in hot solutions of the detergents need not be wiped with towels. They dry in the air without streaking.

AN EMULSION.—Oil and water do not "mix" unless science is called to their aid. You know that if you shake a little olive oil or kerosene with water and let it stand, the oil will separate and rise to the top. The oil rises to the top because it is lighter than the water and will not mix with it. However, when the oil is broken into very small particles by shaking with substances such as soap, the water and oil no longer separate immediately. An *emulsion* is formed *An emulsion is a mixture of oil and water that will stay mixed for quite a while.*

FIELD RESEARCH

Try the following experiment to make oil and water stay mixed. To a test tube two-thirds full of water add a few drops of oil. Shake thoroughly, and allow to stand for a few minutes. Does the oil become finely divided? Do the tiny drops gradually reunite into larger drops and rise to the top?

Now add a few drops of liquid soap and shake vigorously. Is the oil again divided? Do the drops reunite as before or do they appear to remain mixed throughout the water? If the drops reunite, add more soap and shake.

If you have succeeded in making the oil and water stay mixed for a time, you have made an emulsion. The soap sticks to the tiny oil drops and so prevents their uniting to form drops large enough to rise to the top.

Milk is a natural emulsion. You know, however, that after a while the cream (fat) of the milk will rise to the top. This proves also that cream is lighter than the water in the milk, otherwise it would sink to the bottom when it separates. Have you seen milk that is called homogenized milk? In that milk the fat globules have been broken into such tiny particles that they do not separate from the rest of the milk and rise.

FIELD RESEARCH

Take a small bottle of milk to school and examine a drop of it with a microscope. Try to see the tiny drops of fat.

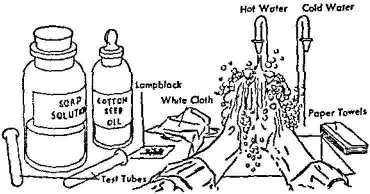
Making Water "Wetter."—Everyone knows that water makes things wet. But do you know that it is possible to make water "wetter"? By that we mean that substances may be added to water which enable the water to soak into materials better.

To understand this, we must realize that the surface of water acts like an elastic film. To some extent the film tries to keep water away from the things it touches; that is, the water soaks into many materials only a little way.

If the surface film of the water could be broken or weakened, the water would be better able to soak into the things it touches. In other words, the water would be wetter. This is what soap does.

EXPERIMENT 36

How does soap remove dirt?



This experiment calls for you to do things with which you are very familiar. The difference is that in the experiment you have set up certain controls to help prove that the effects obtained are really due to soap.

WHAT TO USE.—Test tubes, oil or grease; lampblack (finely powdered charcoal), a liquid soap solution; a white cloth; and paper towels

WHAT TO DO.—1 Smear the inside of a dry test tube with oil. First try to rinse the oil out with water. Then try shaking soapy water in the tube and rinsing. Observe the appearance of the oil and soap after you have shaken the tube and contents.

2 Rub a little lampblack into the white cloth. Try to wash it out with plain water and then with water and soap, using a good lather. Examine the lather to find if it has taken up the carbon.

3 For three pupils. Let one wash his hands with plain warm water. Dry with a paper towel. Look for dirt on the towel.

Let the second pupil wash his hands with warm water and soap. Make a good lather and work it on the skin thoroughly. Now rinse the hands thoroughly with warm water. Dry with a paper towel. Compare the respective amounts of dirt on the two towels.

Let a third pupil use cold water and soap, and cold water for rinsing

WHAT HAPPENS.—1. By which method was the oil better removed from the tube? What did the soap do to the oil?

2 By which method was the charcoal better removed? How did the soap help?

3. If the washing and rinsing removed the dirt satisfactorily, no dirt would be left on the hands to be rubbed off by the paper.

Which method removed the dirt from the hands the best?
What do you think helped to hold the dirt on the hands?

CONCLUSION.—Explain the actions of soap in removing the dirt in each case.

APPLICATION.—Explain why mayonnaise (a mixture of oil, lemon juice and egg yolk) stays mixed better than the oil and lemon juice alone. What is the use of the egg yolk?

When soap is added to water, the surface film of the water is made weaker. This effect enables water to soak into fabrics faster and farther than it could otherwise. The solution can also creep along the cloth surfaces and surround dirt particles better than plain water. Rinsing carries off the loosened dirt particles in the film which the water forms with the soap. The soap and water combination is an ideal team for cleansing purposes.

SOAP AS A CLEANSING AGENT.—By "dirt," as referred to on our clothes and bodies, is meant the daily accumulation of dust, dead skin tissue, and other particles held there by an oil. It is the purpose of soap to help remove such dirt. You have discovered that soap will *emulsify* fats and oils so that they will mix with water. You have also discovered that soap and water will soak into fabrics readily and loosen dirt particles. It is these two properties on which the cleansing action of soap depends.

You will be interested to try Experiment 36 which tells you some good tests to be made with soap.

Hot water is usually better for use with soap to clean greasy materials. In order that the soap can emulsify grease quickly, the grease or fat must be melted. Hot water melts the common greases and fats such as occur on the skin, cloth, or dishes.

LAUNDERING FABRICS.—Proper laundering of fabrics not only keeps them clean and wholesome, but lengthens their life. Clothing, especially that worn next to the body, absorbs perspiration. The skin also gives off fatty or oil substances that lodge in the clothing. Worn-out tissue from the skin becomes entangled in the fabric. Such conditions make frequent laundering necessary.

Ewing Galloway

A Hospital Laundry.—Soiled clothing and linen are brought directly to the washing machines through the hoppers above. Here one washing machine is being loaded. Each machine shown in this picture will wash 650 pounds of dry wash in one hour.

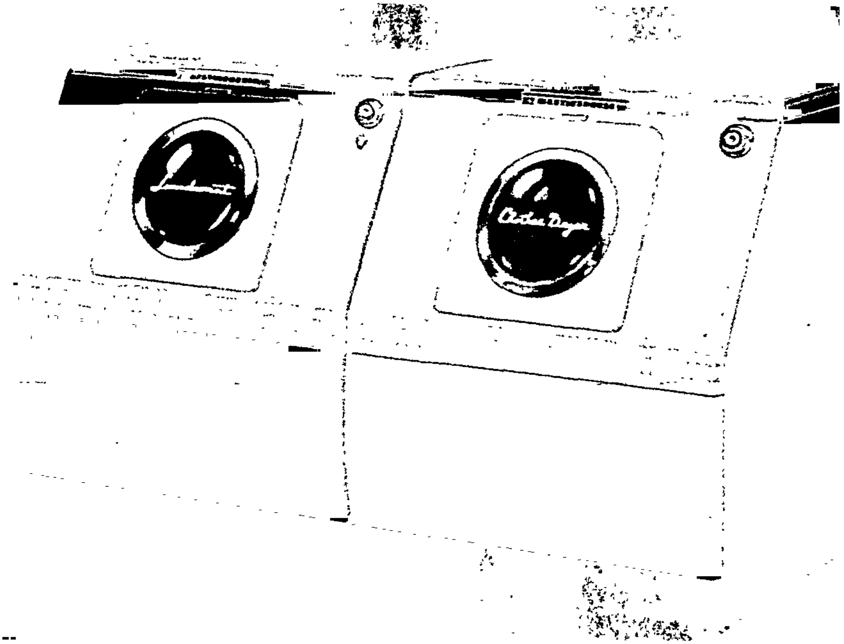
When washing fabrics, care must be taken not to cause them to shrink or to lose their color. Woolen fabrics, especially, shrink very easily. They should be washed in lukewarm water with a mild soap.

Washing powders and bleaching agents should be used cautiously If the water is hard, you can save soap by adding the correct amount of washing soda, borax, or other water softener. The water softener should be thoroughly dissolved before soap is added to the water. Why?

FIELD RESEARCH

Arrange, if you can, to visit a modern laundry.

White cottons should be washed and rinsed with water at a high temperature (approximately 160° F.). A good temperature for colored cottons is about 130° F. For silks, rayons, and wools, 110° F. is about right.



Courtesy Westinghouse

Mother's Modern Helpers.—The machine on the left is a washer which automatically washes, rinses, and damp-dries laundry. Then the machine turns itself off. Next the laundry may be placed in the automatic drier on the right to complete the job.

Sometimes when white fabrics are washed with soap they are slightly discolored. In such a case they may be *blued* to make them look white. Too much bluing, of course, leaves a blue appearance.

WASHING MACHINES.—The modern washing machine makes it possible for soap and water to do their work most effectively. The machine helps in forming an emulsion. It also helps the soap and water to soak into the cloth. This is done by various types of motions. It does not rub. Therefore the clothes are made cleaner with less destruction to the fabric. With a minimum of wear and tear on the cloth, the modern machine also rinses away the emulsified grease and loosened dirt.

Then, too, the old method of wringing clothes by hand was hard work and bad for the clothes. The wringer which squeezes the clothes between rubber rollers is an improvement over hand wringing. Even this method is hard on the buttons.

Some machines use centrifugal force to damp-dry the clothes. The water is pumped out of the tub, and the bowl is whirled very rapidly Centrifugal force carries out most of the water in the clothes.

FIELD RESEARCH

Try this out of doors Saturate a cloth with water Roll it into a compact ball Tie a short, strong string about two feet long to the ball and whirl it rapidly on the string What happens to the water in the cloth?

STAIN REMOVAL AND DRY CLEANING.—Because so many modern fabrics contain synthetic materials and dyes, complete stain removal has become a very exacting procedure. Whenever there is any doubt about the fabric or the dye, do not attempt to remove the stain. If possible send the article to a good cleaner. Tell the cleaner what caused the stain. If it is necessary to remove stains at home, a few simple rules will help.

Many stains are caused by fats or oils. Other common stains are caused by fruit juices, tea, coffee, chocolate, ink, or grass Water will remove some spots. It has no effect on others. The following classification of stains will help you know how to remove them:

A. Stains soluble in water, cold or hot.

B. Stains insoluble in water.

1. Stains soluble in denatured alcohol (inflammable), carbon tetrachloride (non-inflammable), or chloroform (non-inflammable), or some similar new materials, such as trichlorethylene. *CAUTION. On account of its inflammability, gasoline should never be used in the home for cleaning clothes or other materials.*
2. Stains emulsified by soap solution.

C. Stains insoluble in above liquids.

1. Stains on white cotton goods may be bleached with chlorine compounds and bleaching powder solution, such as Javelle water. (See directions for making and use as given on a can of chloride of lime.) Do not use Javelle water on colored goods, since it is likely to bleach out the color as well as the stain.

National Institute of Cleaning and Dyeing

Dry Cleaning.—Dry cleaning solvents dissolve grease and soil from clothing. The dry cleaning apparatus looks much like a laundry machine, but no water touches the clothes. At right a "spotter" removes by hand any spots left after the first treatment. Note the many bottles of different solvents.

2. Stains on woolen, rayon, and silk fabrics may be bleached with an alkaline solution of hydrogen peroxide, with sulfur dioxide, or sodium bisulfite, or sodium perborate.

   Chlorine compounds, such as Javelle water, *must not* be used with silk, rayon, or wool.

Coffee, chocolate, and tea stains can usually be removed by warm soap and water, followed with weak acetic acid.

It is particularly important to be careful in handling colored goods. If the stain is not removed by carbon tetrachloride or warm water and neutral soap, it is best to have a good dry cleaner do the job. Oil and grease stains are best removed by carbon tetrachloride. Grass stains are soluble in denatured alcohol. Iodine stains often may be steamed out of clothing. They may be removed from the skin by rubbing with diluted household ammonia.

Dry cleaning is a process of cleaning fabrics without the use of water. In the early days of dry cleaning, gasoline was used. However, it is no longer used because it is not only dangerous, but leaves an unpleasant odor. Modern cleaning liquids are non-inflammable. They evaporate from the fabric quickly without leaving any odor. They are obtained from petroleum by distillation.

FIELD RESEARCH

Make stains on pieces of cloth and practice their removal. This will help you if you have need to remove a stain on some garment or table linen.

GENERAL PROBLEM 2

Are Your Habits Health Habits?

WHOSE RESPONSIBILITIES?—For most of us, our health is what we make it. If we know how to take care of our bodies, and do so, the chances are we shall enjoy good health. If, however, we neglect our teeth, abuse our eyes, and eat poor food, poor health will probably result. Furthermore, we cannot expect good health if we practice health habits only part of the time. We must work for health every day. Thus our health habits are among our most important habits.

A CLEAN SKIN.—Keeping a clean skin is one of our first health habits. To understand clearly why the proper use of soap and water on the skin is necessary, we must study the *duties of the skin*. The skin is composed of two main layers. The *outer layer* consists of flat dead cells. They are continually worn off from the surface and are replaced by new cells from underneath

The inner layer of the skin is very much *alive*. It is sensitive to touch, to warmth and cold, and to pain. The inner layer is also supplied with many nerves, and tiny blood vessels called *capillaries*. This layer of skin also contains a great number of little coiled tubes or glands called *sweat glands*.

Your body gets rid of some of its waste material through the skin. Each sweat gland has a *pore* (opening) through the outer layer of the skin. These pores are large enough so that you can see them in your skin if you examine it with a magnifier. If the pores become clogged, the sweat glands cannot get rid of their waste matter. It is like stopping up the drain pipe. If the waste matter is held in the skin, it may cause *pimples* or *blackheads*. Also, if this waste matter is not eliminated it may produce a poisonous condition in the body. Such a condition makes one feel dull and have headaches.

A second important duty of the skin is to help regulate the temperature of the body. You have learned that when liquids evaporate, they absorb heat and so cool the surface. When water from perspiration evaporates it takes heat from the skin. If a person tends to become overheated from violent exercise, the sweat glands pour more sweat out onto the skin. This evaporates and so removes heat from the skin and blood underneath. Thus the body is protected from being overheated. Anything that interferes with these actions may result in overheating of the body. So you have another reason for keeping the pores in condition to do their work.

Besides needing a clean skin for the sake of our own good health, we have a duty towards those about us. A person whose skin is clear and clean is much more pleasing to us than one with a dirty skin. Moreover, a skin which is allowed to become unclean gives off a decidedly objectionable odor. Consequently, keeping the skin clean is a duty which we owe to others as well as ourselves.

A third use of the skin has to do with the sense of touch, temperature, and pain. Some of the nerves in the skin have endings that are sensitive to changes in temperature. Others are sensitive to touch. Thus the skin is important because it helps to give us messages of temperature, touch, or pain.

THE USE OF FACE POWDERS.—Many people use powders (and rouge) to add to or suggest an appearance of cleanliness and freshness. These substances are not good substitutes for soap and water. Moreover, the continuous use of face powders will tend to fill the pores, unless the skin is frequently and thoroughly cleansed.

An occasional use of simple powders, such as *talc*, may be of assistance in preventing the skin from chapping when exposed to severe weather. On the other hand, a clean, healthy skin is not likely to be harmed by frequent exposure to the weather.

Skin blemishes such as moles, pigment spots, birth marks, or warts should not be irritated in any way. Irritating them may result in sores which are difficult or impossible to heal. If they are such as to interfere seriously with one's appearance, a physician-specialist should be consulted. Quack skin and beauty doctors and unprescribed skin preparations should be avoided

YOUR TEETH.—Your health is closely related to the condition of your teeth Poor teeth frequently send poisons throughout the body. Without good teeth food cannot be properly chewed. Hence the food which is swallowed cannot be properly digested by the stomach without extra work.

Thus poor teeth may bring on digestive disorders. Digestive disorders in turn may cause poor teeth. And so the trouble piles up. A good set of teeth helps you eat your way to good digestion and health. So take good care of your teeth. Good care means frequent cleaning, inspection by your dentist, and eating proper foods.

CLEANING YOUR TEETH.—When you clean your teeth, you are making the teeth, tongue, and mouth more healthy. You are safeguarding the entrance to your stomach, helping to prevent decay of the teeth and to make them more sightly. And you are keeping your breath pure and wholesome. Therefore, cleaning the teeth is of great importance. Once a day is not enough to preserve a good set of teeth, much less a poor set. They should be cleansed twice a day at the very least. It is better if they are cleansed after each meal. Learn how you can thoroughly cleanse your teeth, and practice the method regularly. You will save yourself many an ache and many a dollar. Careful brushing is an essential part of the care of the teeth. Also use dental floss to clean between the teeth. Ask your dentist about the best tooth pastes and powders.

Recent experiments indicate that the chemical *fluoride* helps prevent tooth decay by about 45 per cent. The fluoride treatment seems to be best if it is started when the child is about four years old. Then it should be followed at intervals by a series of brief, painless treatments until he is thirteen years of age.

VISIT YOUR DENTIST.—Regular cleaning will help keep your teeth in good condition. But cavities do occur, even with the

Harold M. Lambert *N.Y.C. Emergency Relief Bureau*

Teamwork.—Care of your teeth is *your* responsibility, but the dentist is on your team.

best of cleaning. They are small at first, easy to fill, and cause little if any discomfort. However, if neglected, the cavity grows larger and larger. It becomes painful and difficult to care for.

Therefore it is a good idea to have your teeth inspected by your dentist at least twice a year. The dentist will find the small cavities and repair them before they ruin the teeth.

Foods for Healthy Teeth.—Foods containing calcium, phosphorus, and other minerals are necessary for proper growth of the teeth. These minerals are most abundant in fresh green vegetables. It is therefore important for you to include these foods in your diet. Scientists have also found that vitamin D is necessary for the proper use of these minerals within the body. An excellent source of vitamin D is sunshine. Vitamin C, found in certain fruits such as oranges, grapefruit, and tomatoes, is needed to keep gums healthy. Proper diet is of great importance to the formation of good teeth in young children. It is also necessary in maintaining healthy teeth in older boys and girls.

Two Sets of Teeth.—Every person has two separate sets of teeth. The first set to appear is called the baby teeth or the *temporary* set. They "fall out," really are pushed out, at an early age to make place for the *permanent* set.

FIELD RESEARCH

Make a special study of food requirements for good teeth. Make a list of what you eat for two or three days and check this list to make sure you are getting the necessary foods.

The first of the permanent molars appear when a child is about six years old. These "six-year molars" are frequently mistaken for baby teeth. They appear about the time the child loses his front baby teeth and replaces them with larger permanent ones. They are usually the first of the permanent teeth to show and frequently have flaws in their enamel covering. Therefore they should be given special attention by the dentist as soon as they push through the gums.

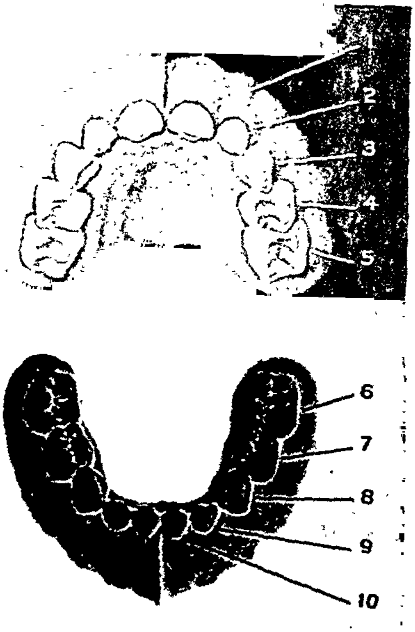
Sometimes the baby teeth are neglected because they are considered temporary. However, the child's baby teeth should be given just as good care as the permanent teeth.

There are only 20 teeth in the baby set, but 32 in the permanent set, as shown in the pictures. The third molars (wisdom teeth) often do not appear until about age 24 or 25. Sometimes they never emerge. Before the permanent teeth appear, the roots of the first teeth are absorbed. Then the new teeth push through the gum causing the crowns of the baby teeth to fall out.

PARTS OF A TOOTH.—It is a good thing to recall what you know about the *structure* of your teeth, for it will help you in your care of them. A tooth may be considered as divided into three parts. The *crown* rises above the gum. The root holds the tooth in a bony socket of the jaw. The short portion between the crown and the root is called the *neck*.

Over the outer surface of the crown is found a layer of very hard mineral matter called *enamel*. The enamel layer is thickest on the biting end of each tooth and thinnest at the neck.

Inside the tooth is an ivorylike substance called *dentine*, which is similar to bone. Inside the dentine is the *pulp chamber*, which holds the pulp of the tooth. The pulp is composed of connective tissue, nerve tissue, and blood vessels. Through the blood vessels food for the tooth is carried to it, and waste prod-



Courtesy American Dental Association

First Set of Teeth:

1, 10. Central Incisors.
2, 9. Lateral Incisors.
3, 8. Cuspids.
4, 7. First Molars.
5, 6. Second Molars.

Courtesy American Dental Associa

Permanent Set of Teeth:

1, 16. Central Incisors.
2, 15. Lateral Incisors.
3, 14. Cuspids.
4, 13. 1st Bicuspids.
5, 12. 2d Bicuspids.
6, 11. First Molars.
7, 10. Second Molars.
8, 9. Third Molars.

ucts are carried away. The nerves supply the tooth with sensation. These blood vessels and nerves connect with the other blood vessels and nerves through a small opening at the end of each tooth root.

Tooth Decay.—*Although it may not be strictly true that a* "clean tooth never decays," certainly uncared-for teeth decay much more quickly. The decay of a tooth is closely connected with the breaking, cracking, or disappearing of the enamel. Decay is also related to the eating of improper foods. However, scientists do not agree on all the causes of tooth decay.

Particles of food between the teeth make good breeding places for bacteria. The bacteria give off an acid which may dissolve the enamel and cause the dentine to decay. This decaying process often continues inside the tooth for a long time before it is noticeable except to a dentist. See your dentist often!

Another possible cause of decay is a receding of the gums. The portion of the tooth not protected by enamel is thus exposed to the action of bacteria. Receding gums may be a symptom of a disease called *pyorrhea*. If allowed to continue, it almost certainly results in early loss of the teeth. If this condition occurs, a specialist should be visited at once.

Your teeth are constantly bathed in saliva. Saliva, you remember, is formed in the glands of the mouth. Some dental research workers believe that the saliva is important in the protection of teeth against decay. Just how saliva does this is not as yet fully understood.

The elimination of sweets from the diet will help to slow up the rate of tooth decay. It may prevent decay altogether in some individuals.

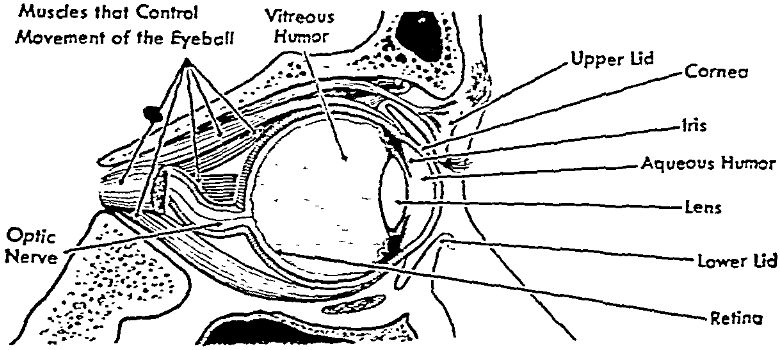
Our Eyes.—Our eyes are living, automatic cameras. Through our eyes comes most of what we learn about our environment. We should understand how our eyes work so that we will be better able to take proper care of them.

The diagram on page 387 will help you review the parts of the eye. We remember that the eye is a ball. Its movements are controlled by several sets of muscles. At the front of the eye are the *cornea* and the *iris*. Light enters the *pupil*, is focused by the *lens*, and falls upon the *retina*. Nerves from the retina carry the sensation of sight to the brain.

Care of the Eyes.—Only a very few people are born with defective eyes. If given proper care, the eyes will remain "sharp" for many years. As a person grows older, however, the lens may lose some of its ability to focus on nearby objects. This is *farsightedness*. It is a normal condition for many older persons.

There are many things you can do to keep your eyes in good condition. When doing close work, the eyes should be rested frequently. This can be done by looking off in the distance. Changing the focus this way gives the lens muscles a chance to change their position.

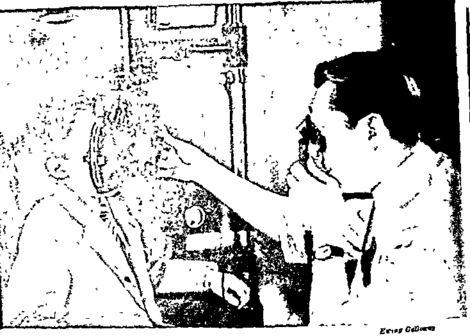
Reading should always be done in good light, with the light coming from over the shoulder. The page should be lighted evenly with no shadows or glare. Glare sends too much light to the retina, and causes the eye to strain to see the print. Shadows cause the eye to adjust continually to different amounts of light, and thus cause fatigue. Fatigue is also caused by trying to read in a flickering light. Reading while in a moving car puts a severe strain on the muscles which control the movement of the eyeball. We should remember that these are the muscles which keep our two eyes working as a "team."



Our Sense of Sight.—Think of the parts of the eye which you can always see in a person's face. Find them in this drawing and name them. Think of the nerve which carries the seeing messages back to the brain. Find it here and give its name. Think of the eye as a ball set in a socket with muscles running back like bands of elastic from all sides of the eye. Why are so many muscles needed? Think of the eyeball as filled with a thick liquid through which the light rays pass back to a kind of film, the retina. What happens to the rays as they enter the eye? How do you know this?

The retina is perhaps the most sensitive part of the eye. Although it is not yet completely understood, eye doctors agree that extremely bright light should not be allowed to fall on it. Thus one should never look directly at the sun, or at an electric arc, or into the bright headlights of a car.

Occasionally "something" gets into an eye. A small cinder or other substance may get lodged between the eyeball and the lid. Sometimes tears will begin to flow and wash out the sub-



Ewing Galloway

An Eye Examination.—Does this picture help you to understand the importance of science in caring for our eyes? An eye doctor spends many years studying the eyes. Other scientists are developing instruments which will help the doctor in his work.

stance. At other times it may be necessary to remove it. Winking rapidly a few times may help. Rubbing the closed eye with a clean cloth *lightly and toward the nose* may remove it. Sometimes an eyewash will help. If these methods do not succeed, it is best to see a doctor. Further rubbing is apt to scratch the delicate tissues or even force the object into the surface of the eyeball.

Just as it is good practice to see your dentist regularly, so it is good practice to have your eyes checked by a doctor. Boys and girls who do a good deal of reading and close work in school should have their vision tested at least once a year. *Nearsightedness* (opposite of farsightedness) usually develops gradually. Often the person is not aware of it except for frequent headaches. The eye doctor cannot cure nearsighted or farsighted eyes. He can prescribe glasses which bring back clear vision and relieve the eye muscles of strain.

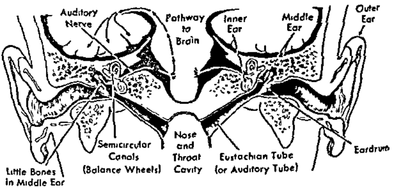
U. S. Public Health Service

An Ear Examination.—Teeth, eyes, and ears need careful and regular examinations by the doctor. He is trained to help you care for your health and prevent trouble. However, you must also help yourself. How can you and the doctor cooperate?

CARE OF THE EARS.—Most boys and girls know the few necessary rules about the care of the ears. It is necessary only to review these rules here.

One of the most important things to remember about the ears has to do with cleaning them. If you refer to the drawing of the ear on page 390, you will see the tube which extends from the eardrum to the outside. A certain amount of wax forms in this tube. Its purpose is to protect the tube and the delicate *eardrum*. You should not attempt to remove all this wax with soap and water. Indeed, some doctors believe soapy water should not be used inside the ear at all. Plain warm water will normally remove any excess wax.

It sometimes happens that too much wax accumulates in the tube. It may even press against the eardrum. If you have ever had "water in your ear" after swimming, you probably had wax against your eardrum. It was pushed there by the pressure of the water. *Never try to remove wax with a toothpick, pencil, or other sharp-pointed object.* If a bit of cotton or a clean handkerchief wrapped around your finger will not remove the wax, see a doctor. An inexperienced person who tries to remove something from his ear can easily push the object farther into the ear. You should never take the chance of puncturing the eardrum.



Our Sense of Sound.—Think of the part of the ear you can see on another person. Find it in this drawing and name it. Think of the nerve which carries the sound messages to the brain. Find it here and name it. Think of the thin tissue which is set vibrating when sound waves strike it. Find it here and give its name. Think of the three little bones that are set vibrating. Find them and name them. Think of a carpenter's tool that works in much the same way as the semi-circular canals. What is it?

The ears should always be protected when diving in deep water. A swimming cap will prevent the water pressure from pushing too hard against the eardrum. Air pressure as well as water pressure can also damage the eardrum. For this reason you should never let anyone slap your ears. Nor should you slap another person on the ears.

The *Eustachian tube* shown in the diagram connects the ear with the throat. Thus a throat infection may possibly be carried to the ear. Proper ear protection demands that you never let any throat infection go untreated. Another way to cause ear infections is by blowing the nose with one nostril pressed shut. Do not blow your nose unless both nostrils are open.

What Are Some Scientific Defenses against Disease?

PREVENTION AND TREATMENT OF DISEASE.—Science wages the battle against disease on two fronts. It tries to *prevent* disease, and when disease occurs, it tries to *cure* it. Much of the prevention of disease has to do with cleanliness and sanitation. We have already learned how garbage and sewage are disposed of so that they will not be a source of disease. We have learned of the importance of soap and water in keeping our bodies, clothes, and homes clean.

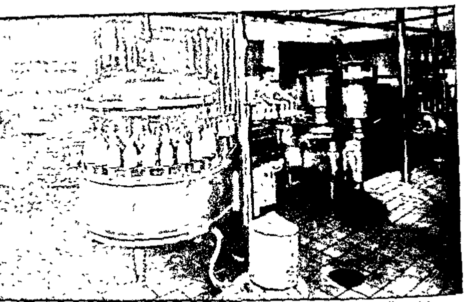
We know that the water supply of a community is a danger spot unless it is safeguarded from disease germs. Our study has shown how much care is taken to provide an abundant and safe supply of drinking water.

THE MILK SUPPLY.—The milk supply is also a danger spot unless it, too, is safeguarded from disease germs. Unfortunately milk is just as good a food for bacteria as it is for you. Therefore, the problem is to produce milk and deliver it to your table with as few germs in it as possible. It must not have any disease-causing germs.

The first requirement in the production of safe milk is to have cows that are free from disease. Stables must be kept clean and well ventilated. If cows are milked by hand, pails should have a small opening in the top rather than a large open top. This is to prevent dust from entering. The cows should be cleaned before milking and the attendants should be clean and free from contagious diseases. The milk should be chilled as quickly as possible to prevent the increase of any germs that may be present.

For community use the milk is collected from the farms and taken to the dairy. There it is first weighed and samples are tested. It is then pasteurized and bottled.

Some milk is bottled raw, but even with the greatest care disease germs may be found in raw milk. Therefore, it seems best to pasteurize all milk and cream. This is usually done by heating the milk from 142° F. to 145° F. for thirty minutes.



Bottling Milk.—Sanitation is the key word in modern dairies. This machine is an automatic bottler. Pasteurized milk is poured into the bottles which are then capped in a continuous operation. Why is this a better procedure than filling the bottles by hand?

Pasteurizing kills all the possible disease germs, but not all harmless germs Pasteurization may destroy Vitamin C. That is not too important because Vitamin C is available in orange and tomato juices and in other foods. Children appear to grow just as well on pasteurized milk as on raw milk. We shall discuss pasteurization in more detail when we study the use of heat in food preservation.

FIELD RESEARCH

Appoint a committee to find out from the Public Health Bureau what diseases may be transmitted by milk. Learn also about any recent milk-borne epidemics.

Another committee might be appointed to inspect a dairy and report to the class on how the milk is pasteurized and bottled. Perhaps arrangements can be made for the whole class to visit the dairy.

Most states, cities, and towns have laws governing the protection, care, and sale of milk. You will be interested to get a copy of those laws. Study them and make sure that milk delivered to your home or school meets the requirements.

Unused milk is made into various milk products such as butter and cheese. Some milk is "evaporated" and canned. Large quantities of milk are "powdered." This is done by spraying very finely divided milk into a room where the air is warm and dry. The dry air quickly absorbs the water from the milk, leaving it in powdered form. Another interesting kind of milk is called "homogenized." This milk has had its fat globules broken into fine particles. As a result the cream (fat) does not rise to the top of the milk. Some milk is treated with ultraviolet light which appears to increase the amount of Vitamin D, the sunshine vitamin.

Another milk product is chocolate milk. Chocolate milk is supposed to be made by adding a little sugar and chocolate to whole milk. Therefore, it will have a good amount of fat, approximately 3.8 per cent. It is a wholesome drink. In many parts of the country, however, chocolate milk is made from skim milk. *Often it is called "chocolate drink" or chocolate* chill." Its fat content may be as low as 2 per cent or 2.5 per cent.

Milk is most important in your diet because it contains easily digested fat and a good quality of protein in the best proportion for young people. Even more important are the calcium and other minerals which milk contains. These minerals are required for the development of good teeth and bones. Milk is especially rich in Vitamins A and B_2 (G). Vitamin A is especially important in preventing night blindness. Vitamin B is sometimes called the "pep" vitamin. Milk also contains most of the other vitamins although in smaller amounts.

Good milk is made up approximately as follows:

Fat	3.5—4%
Proteins	0.7—1.5%
Lactose (sugar)	6.0—7.0%
Minerals	0.15–0.3%
Water	87.5%
Vitamins	A and B_2 (G) and others

Be sure you get a quart or more of safe milk every day for your teeth and bones' sake. It is good—drink plenty of milk.

The Bettmann Archive *American Red Cross*

Then and Now.—(Left) Dr. Jenner gives the first vaccination for smallpox. This shows the use of a *vaccine* to prevent a disease. (Right) A boy is being innoculated with a *serum* following his exposure to measles. The serum will *not* prevent the disease but will spare the boy from a serious case.

Inoculations against Diseases.—In most states children must be vaccinated against smallpox before they begin school. The vaccination is a very simple process. A drop of liquid containing some weakened smallpox germs is placed on the skin. Then the doctor scratches the skin with a sharp needle through the drop. The weakened germs enter the body. They cause the body to build up an immunity (defense) against the disease. The immunity lasts for several years. In time it may disappear. Then it is necessary to be vaccinated again.

Typhoid fever can also be prevented by vaccination. Typhoid *vaccine* consists of dead typhoid germs A doctor injects the vaccine under the skin of the arm. Anyone who travels in regions where the water supply is not absolutely safe should be vaccinated against typhoid fever. Other diseases which can be prevented by vaccinations are diphtheria, tetanus (lockjaw), and whooping cough.

Vaccinations, like those described above, are valuable only if given before the person is exposed to the disease. They build a natural immunity which fights off the disease. Often, however, a person is exposed to a dangerous disease against which he has not been vaccinated. Then it is too late to use a vaccine. The disease germs work faster than the vaccine. In such cases a *serum* is used. There are many different kinds of serums, but they all help fight diseases *after* they are "caught." There is a serum for diphtheria. When injected into the body, it fights the poisons of the diphtheria germs. Serums are also used to fight such diseases as scarlet fever, pneumonia, and tetanus.

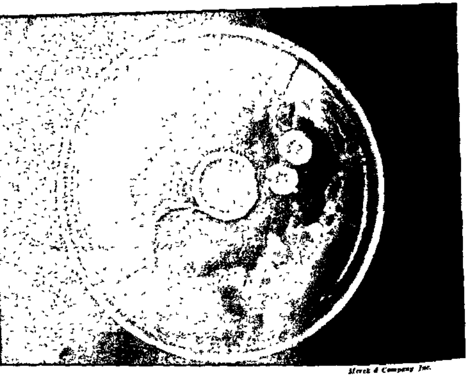
We should remember that vaccinations protect against catching the disease. They build immunity in the body. Serums are used to fight the disease after it strikes or during exposure to it. Serums do not build up immunity.

SULFAS AND ANTIBIOTICS.—Almost every boy and girl has heard of the *sulfa drugs*. About 20 years ago it was discovered that these chemicals were valuable aids in fighting certain diseases such as throat infections. Many different sulfa drugs have been made in the laboratory during recent years. Most of them have been given long names, but they all begin with *sulfa*. For example, *sulfathiazole* is one of these drugs. These drugs may have some harmful effects; therefore they should be used only on the advice of a physician. They are not "cure-alls," but when properly used they do help fight certain types of infections.

World War II brought forth the "wonder drugs." The first of these was *penicillin*. Discovered by accident in 1928, little attention was paid to it until about 10 years later. Then penicillin was developed for use, and became perhaps the most famous drug of the war.

Any drug produced by a living organism is called an *antibiotic*. Penicillin is produced by a mold which grows in the soil. Since the discovery of penicillin, many other antibiotics have been developed from soil molds and bacteria. *Streptomycin*, *aureomycin*, *terramycin*, and *chloromycetin* are already common names. And dozens of still newer antibiotics are being developed and tested. Pneumonia, scarlet fever, typhoid fever, bone infections, and throat infections are just a few of the diseases already conquered by the antibiotics.

ACTH AND CORTISONE.—*ACTH* is a fluid produced by a gland at the base of the brain. *This fluid acts on certain other*



Merck & Company Inc.

Penicillium.—The circles with white rings are colonies of the mold *penicillium.* Penicillin is obtained from this mold. Notice that the colonies are surrounded by a clear area. The clear area is a region where the penicillium has prevented the growth of bacteria. Farther away from the colonies is a grayish region where bacteria are growing. What is the effect of the mold penicillium on the growth of bacteria?

glands which produce a fluid called *cortisone.* Recently it has been discovered that ACTH and cortisone (obtained from animals) produce dramatic effects in treating certain diseases of the joints. Apparently these drugs do not cure disease. They seem to keep the disease under control. The use of both ACTH and cortisone is very new. Scientists are not at all sure just how they work in the body. Perhaps experiments with these materials will lead to discovery of what happens in the body when a disease strikes. Then may come better ways of fighting disease. At any rate we may be sure that scientists will never give up their constant battle to conquer disease.

What Is Your Responsibility for Safety and First Aid?

Accidents in the Home.—Did you ever fall down stairs or have a rug on a slippery floor slide out from under you? Do you know of anyone burned from hot grease catching fire on the stove, or from a gasoline explosion? If so, could these accidents have been prevented? Every day, everywhere, accidents of one kind or another are occurring in homes. It is said that there are more accidents in the home than anywhere else. Some are serious—resulting in broken bones, asphyxiation (ăs-fĭk′sĭ-ā′shŭn), blood poisoning, and even death. Others are minor accidents such as sprains, bruises, burns, or cuts. Accidents, whether big or little, are due to two causes: carelessness and misjudgment. Thoughtfulness will prevent those due to carelessness. Knowledge will help to prevent the others.

Kinds of Accidents.—In the home, accidents fall into several groups:

1. Those caused by falls from chairs or steps; or on rugs that slip, or have worn places in them; or over tools and playthings left in unexpected places; or in slippery bathtubs; or in badly lighted places.
2. Those caused by burns or scalds from carelessness about stoves, heaters, electric cords, and cleaning fluids.
3. Those caused by asphyxiation from carelessness about open gas jets, leaky gas pipes, defective furnaces, gas and oil stoves, and automobile engines running in closed garages.
4. Those caused by poisons from failure to label the poisons properly and failure to put them out of reach of children.
5. Those caused by shock from handling electrical fixtures with wet hands.
6. Those caused by careless use of sharp tools, and so on.
7. Those caused by guns and ammunition from failure to put them out of reach of children.

After you have read these seven ways in which accidents may happen in the home, discuss each one. Try to plan how they may be prevented. Of over 30,000 *fatal* home accidents each year more than half are from falls. About one sixth are from burns. Next are those from poisons, suffocation, and firearms. Perhaps you will think of other ways accidents may happen in your home. If so, add them to the list. The way to prevent accidents is to plan in advance so they cannot happen. It is better to be safe than sorry.

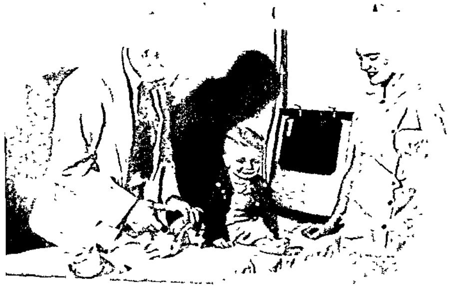
First Aid for Accidents.—Each of the accidents mentioned above may require special treatment and may need the services of a doctor. This book cannot tell you what to do in each case, and it does not take the place of a trained nurse or physician. All that can be done in a science book like this is to point out first things to do and things not to do in case of an accident.

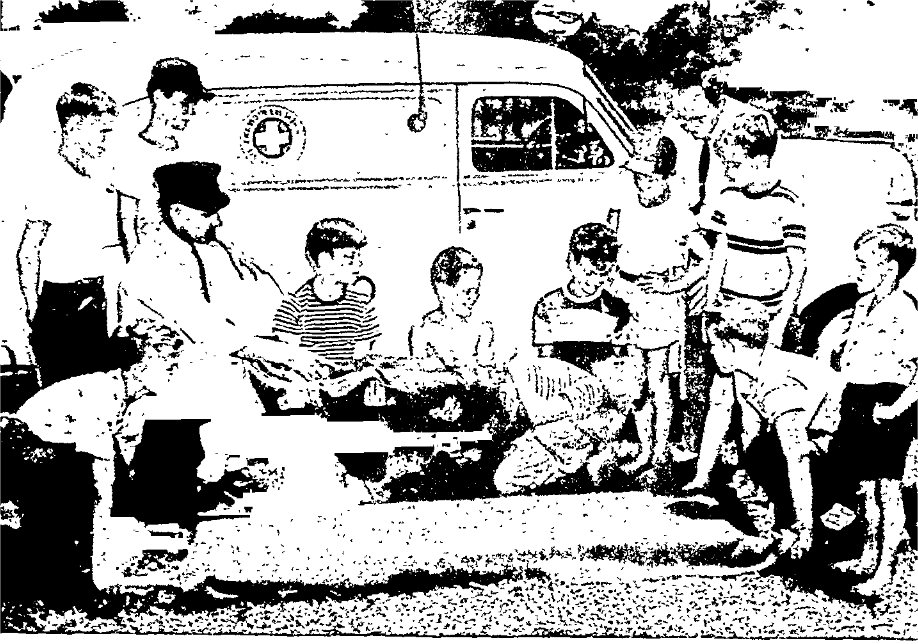
The first rule in every accident is to "keep your head." Do not get excited. If you do, you may cause additional harm. In case of accident act quickly, use good judgment and skill, and you may save a life.

Broken bones, dislocated joints, sprains, and bruises result from falls. *Bruises* should be treated with disinfectants to prevent infection of any kind. Even the slightest bruise is a danger spot, particularly if the skin is broken. A scratch in the skin is the open door for the entrance of germs that may cause inflammation or blood poisoning.

Big Trouble for a Little Boy—Accidents do not respect age. You have a responsibility to help protect younger children from accidents. How can you do this?

Courtesy The Children's Hospital of Boston





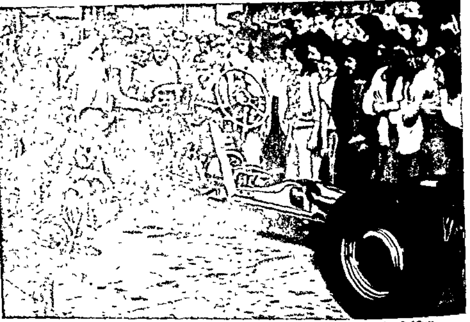
American Red Cross

First-Aid Class.—Part of a good summer playground program is first-aid training. The fire department and Red Cross cooperate to teach first aid to these boys in North Carolina. Are you a good first-aider? How can you train yourself so that you will be ready in case of emergency?

Broken bones and dislocated joints require the immediate attention of a physician. You should make the patient as comfortable as you can, where he fell. Moving him may make the fracture worse. Relieve the injured bone from strain by protecting it from being jarred. Do not try to treat the patient in any other way, except by giving him hot drinks in case of nervous shock.

Strains and sprains should be treated with cold, wet applications (not ice) until the doctor comes. Sprains are more serious than strains, and are due to a tear in the ligaments of a joint. Sometimes it is difficult to tell a sprain from a fracture; so it is best to call a doctor. Strains and sprains may need to be bandaged.

Burns and scalds may be treated with oils, baking soda, or limewater. These relieve the pain and protect the spot from



American Red Cross

First Things First.—This cut-away automobile is used in a school accident prevention program. These students will be better drivers if they know the "why" of an automobile as well as the "how."

the air Beware of infection Blisters should not be broken Severe burns require the attention of a physician.

Asphyxiation occurs from the shutting off of oxygen to the blood supply It may result from breathing air contaminated with poisonous gases such as carbon monoxide, coal gas, or smoke fumes. Fresh air and artificial respiration should be given until the doctor arrives.

Poisoning is treated in various ways, according to the kind of poison taken Labels on the bottles usually give the "antidote" or directions for treatment. Bottles containing poisons should be odd shapes so they cannot be mistaken for other bottles even in the dark. Of course, poison bottles should be kept out of reach of children.

A *gunshot wound* needs a physician's care. Keep the patient quiet. Treat for shock if necessary. If there is much bleeding, it must be controlled as directed under cuts.

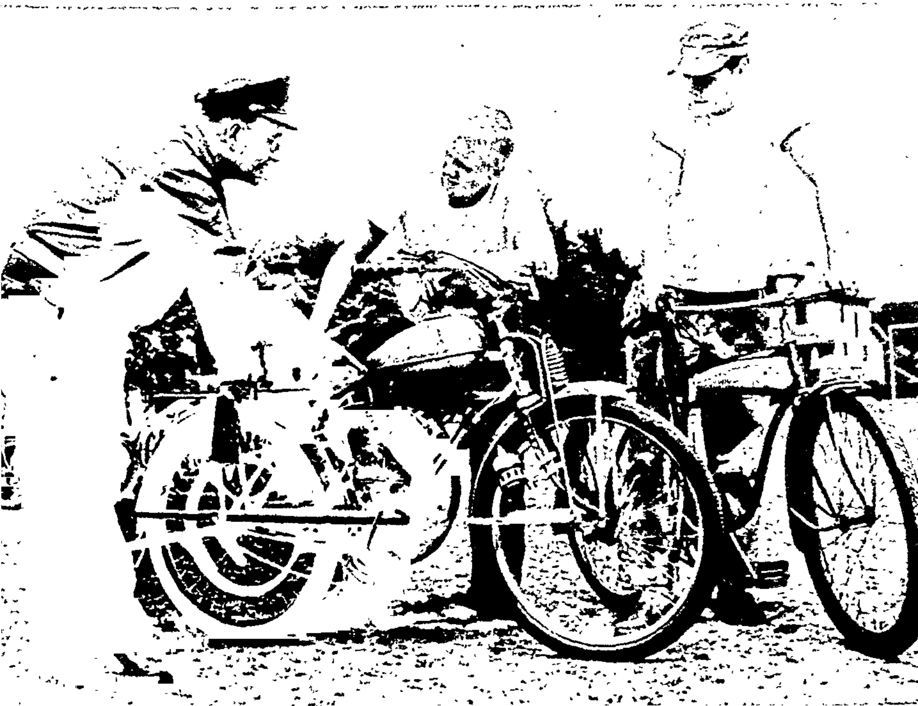
Shock from electricity or lightning may be treated with artificial respiration.

Cuts are of two kinds: small, surface cuts, and deep, ugly cuts where a vein or an artery is severed. Surface cuts may be safely treated with a disinfectant. *Call a doctor at once* if a vein or artery is cut. These cuts will bleed heavily. The blood from an artery is bright red in color, flowing in spurts. Blood from a vein is a dark red in color. It flows in a slow, steady stream. The bleeding in both cases must be stopped. In the case of an artery, apply pressure between the wound and the heart to stop the flow of blood. In the case of a vein, apply pressure on the side of the wound away from the heart.

In the case of a very bad cut, a tourniquet is sometimes used. It is a tight bandage, with a lump in it to press on the cut vein or artery. Because of the danger of blood poisoning, it should not be used until all other measures fail. The tourniquet should be loosened a little every few minutes to permit some circulation of the blood.

Bicycle Inspection.—Many communities have required bicycle inspection. Even if your town does not require inspection, you have a real responsibility to keep your bicycle in proper order. Brakes, light, horn, and solid frame are some points to be checked frequently.

Courtesy National Safety Council



ACCIDENTS OUTSIDE THE HOME.—Most accidents outside the home involve automobiles, bicycles, or swimming. There are so many automobile and bicycle accidents that every boy and girl should know how they happen. Your department of public safety will tell you the number, cause, and time of day of most automobile accidents Fast driving, driving by an intoxicated driver, driving with faulty brakes, driving with insufficient vision, taking curves too fast, passing on hills, and taking chances are a few of the causes of auto accidents. What can you do about it? You can refuse to ride with unsafe or unskilled drivers. It is not being sissy-like to object to recklessness in driving. It is just being sensible.

Many pedestrians are injured or killed due to their own carelessness You know how to be careful—so be careful.

If you ride a bicycle, you can obey the traffic rules. Each year there are about 35,000 bicycle accidents which result in over 700 deaths. Remember, if your bicycle and an automobile collide, your bike will get the worst of it.

There are thousands of swimming accidents every year resulting in nearly 5000 deaths. Can you swim? If you cannot, then learn to swim at the very first opportunity.

THINKING THINGS OVER.—As you think back through this topic, you will remember that personal health and safety involve many things. Soap and water are our most important aids to cleansing Do you know how they work to remove dirt? Do you know why soft water makes a better partner for soap than hard water?

We know now that health is not an easy goal to reach. We must work toward it every day. Are you building health habits? Do your health habits include care of your skin, your teeth, your eyes, and your ears? Fortunately, we are not alone in our work for good health. Scientists have discovered, and are still discovering, defenses against diseases. Scientific controls protect our water supply and our milk supply. Vaccinations protect us against diseases we may become exposed to. Serums, sulfa drugs, and antibiotics help cure diseases after they strike

But we as individuals must accept much of the responsibility for our own health and safety. Thus this topic has included a study of safety and first aid. Do you know the important rules of protecting yourself through safety? And do you know the rules of first aid? In the case of an accident, a knowledge of first aid may save your life or the life of another person. Are you ready?

Key Words

accident	emulsion	litmus paper	soft water
alkali	enamel	minerals	sulfa drugs
antibiotics	farsighted	molar	sweat gland
artery	fat	nearsighted	teeth
burns	first aid	permanent hardness	temporary hardness
cavity	fracture	serum	tourniquet
dentine	glycerine	skin	vaccination
detergents	hard water	soap	vein
eardrum	lime		

Key Statements

1. "Hardness" of water is caused by calcium and magnesium bicarbonates and sulfates dissolved in the water.

2. "Temporary hardness" can be decreased by boiling. It is caused by calcium bicarbonate and magnesium bicarbonate. These minerals decompose when heated.

3. "Permanent hardness" is not affected by boiling, but can be decreased by the use of water-softening agents. It is caused by sulfate of calcium and of magnesium.

4. The principal function of soap is to act as a cleansing agent.

5. The cleansing action of soap depends upon its ability to emulsify fats and oils and to help water loosen dirt particles.

6. Soap substitutes contain no soap, but are valuable because they soften water and loosen dirt.

7. Water-softening substances used with hard water before adding soap results in a saving of soap.

8. Soap is made by the action of an alkali on a fat or oil.

9. An oil emulsion occurs when the oil is so finely divided by an emulsifying agent that it will stay mixed with water.

10. The treatment of a stain for its removal depends upon the character of the stain.

11. The skin regulates temperature, gives off wastes, receives sensations, and protects the body. It functions best when clean.

12 The evaporation of the moisture of perspiration from the skin acts as a cooling process to prevent overheating of the body.

13 The three main parts of a tooth are. crown, root, neck.

14 Diseased teeth are responsible for many ills of the body.

15. Proper diet and regular cleaning are necessary to prevent tooth decay

16 Proper care of the eyes includes: protection from glare, reading in adequate light, not doing close work for long periods of time, and having eye examinations regularly.

17. The eardrum may be broken by sharp objects, or unequal air or water pressure

18 A safe milk supply requires sanitary production and handling Milk should be tested regularly

19 Sulfa drugs, antibiotics, and inoculations are modern scientific methods of fighting diseases.

20 Accidents are due to two causes, carelessness and misjudgment.

21 A knowledge of "first aid" is of value in the treatment of accidents until a doctor arrives

22 Most accidents can be prevented

Thought Questions

1 Why does hard water require more soap to form a suds than rain water?

2 How can you soften water containing bicarbonates? sulfates?

3 What is hard water?

4 Why should a water softener be used *before* soap is added?

5 Is a detergent a soap? Explain.

6 What are the raw materials of soap making?

7. Why does hot soapy water wash better than cold water alone?

8. Explain how whirling wet clothes dries them. How does this differ from what happens when clothes dry on a line?

9 What are some causes of tooth decay?

10 Why is it important to visit the dentist frequently?

11 What part of the eye regulates the amount of light entering?

12 Name three good practices in the care of the eyes.

13 Is wax in the ear an unhealthy condition? Explain.

14. What is the difference between sulfa drugs and antibiotic drugs?

15 Why should children be vaccinated when they are very young?

16 How does the use of serum differ from use of vaccines?

17 Why should every person know something about first aid?

18. Why are there accidents? How can you help prevent them?

PROJECTS FOR YOUR SCIENCE DISCOVERY BOOK

1. Examine all the varieties of soap used in your home. Read on the wrapper what is said about each kind. Test each kind to find which one makes the best lather on your hands. Report your discoveries.

2. Make a collection of household substances and test with litmus paper. List them and indicate in each case whether it is an acid, alkaline, or a neutral substance.

3. Make a report on various laundry equipment machines and their advantages for laundry work.

4. Compare the shape, number, and functions of your teeth with those of a cat or dog. Explain the differences.

5. Make a collection of as many samples of tooth pastes and powders as you can. Read the labels and advertising material that comes with them. Criticize the statements in the light of your knowledge. Are all the claims just? Is each paste or powder safe to use?

6. Make a collection of all the brands of washing powders and water softeners available in your community.

Study the labels to determine what claims are made for each product, and then decide by experimenting and by your knowledge of the facts about such materials, whether or not the claims are valid.

Weigh the contents of each package and from the price of the package and its weight calculate the cost per ounce of each. Try to account for the differences in cost. Compare the cost per ounce with that of washing soda.

7. Visit a plant or a home where water softening equipment is used. Make a drawing of the principal parts. Explain how the equipment works.

8. Plan a visit to a local dairy. Write a brief description about how the milk is kept clean and sanitary.

9. Draw up a good Code of Safety for your household.

10. Draw up a Safety Code for street and highway traffic.

11. Make a list of simple remedies to be kept in the medicine closet and explain the use of each and why you included it.

12. Read about the work of Jenner with smallpox, Alexander Fleming with penicillin, or Selman Waksman with streptomycin. Write a brief report about one of these scientists.

13. Start a collection of newspaper articles about the antibiotics, ACTH, and cortisone.

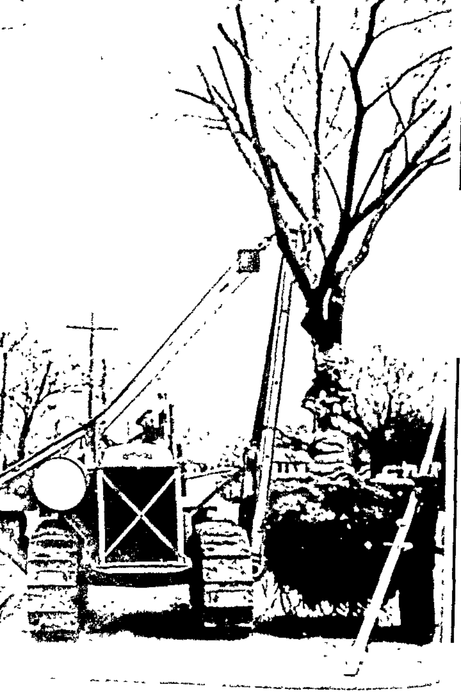
14. Find out what tests for first aid girl and boy scouts have to pass.

Ewing

The Good Earth.—From America's gardens and farms comes food for our country and the world. All food comes from the soil, and the soil produces best when it is cared for and used scientifically.

UNIT V

Farm and Garden



Courtesy Caterpillar Tractor Co.

Traveling Tree.—This live tree is being moved four miles for transplanting. In removing the tree from its original location, care was taken to preserve the roots and the soil around them.

TOPIC XIV

Garden Plants and Planting

DO YOU KNOW—

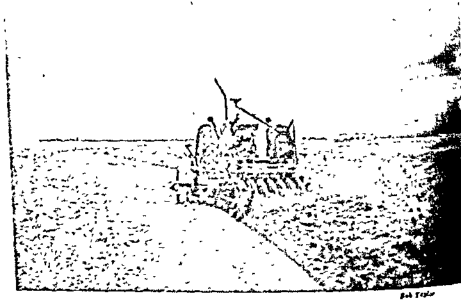
1. How to plant a seed?
2. Why garden soil is worked?
3. Why some seeds that are planted fail to grow?
4. How bacteria in the soil help plant life?
5. What a garden plan is?

GENERAL PROBLEM 1

How Is Soil Prepared for Planting?

WHAT IS SOIL.—*Do you remember that soil is made of* ground-up and weathered rock? Mixed with the rock material are decaying organic matter (humus), water, air, and living organisms. The soil in your garden may have been formed by the weathering and decay of local rock, or it may have been brought from distant places by glaciers or rivers. For perhaps a billion and a half years water has been at work preparing soil for plant growth. Rocks, ages old, have been broken up, ground into tiny particles, and mixed to form soils with a variety of minerals in them. These are the minerals required as plant food. Wind, water, ice, changes in temperature, oxidation, and plants and animals have worked to change barren rock into priceless soil. Thus soil is more than a mixture of lifeless materials. It is teeming with life, and contains life-giving oxygen, nitrogen, and water.

Soils vary widely on account of the substances which compose them. That is why we have clay, sandy, loam, and muck soils. Each requires special treatment and is best fitted for particular crops.



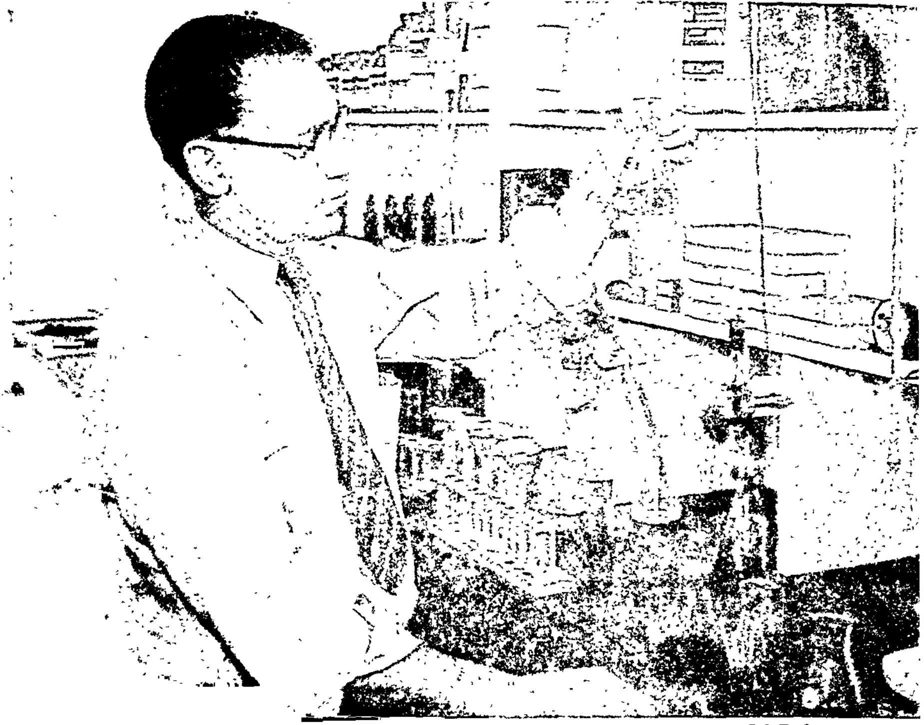
Plowing—The first step in the preparation of soil is plowing. Some soils demand deep plowing. Others, especially if the soil is loose and may blow away easily, need only shallow plowing. What is the reason for plowing? How is the plowing done by farmers in your part of the country?

Soils differ, also, in size of particles, and so we have coarse gravel, fine gravel, and sand. The size of the particles is important in relation to drainage and air and water content. The finer the soil, the more air and water it can contain.

FIELD RESEARCH

Investigate the soil of your neighborhood to determine how it was formed and where it came from.

Parts of the Soil and Their Uses to the Plant.—Every part of the soil has its value to the plant. A successful gardener or farmer must know the parts and their uses. Some of the bacteria in the soil help to decompose organic matter. This releases nitrogen to the air and makes the rest of the matter suitable for plant use. Other bacteria take nitrogen from the



Bob Taylor

Soil Testing.—Successful farmers select the proper crops for their soil. The soil scientist can test soil to find what kind of fertilizers should be used and what crops are best suited to it. Soil testing service is offered by most state agricultural colleges.

air and change it into *nitrates*. Nitrates are needed for plant growth. Without air (with its oxygen) in the soil this work would stop. Some of the minerals dissolve in soil water and are taken up by the root-hairs of plants. They are used by the plant for manufacturing its food.

The humus (organic matter) feeds bacteria and holds moisture in the soil. A mixture of sandy soil containing a little clay and humus (a sandy loam) is best for gardening. Sandy soil, alone, drains too freely and dries out. Clay soil absorbs a larger amount of water than sandy soil. It gets sticky and soggy and does not allow the water to circulate freely. When it dries, it cakes and cracks. Water escapes rapidly through the cracks, leaving dried clay chunks that are difficult to work properly. The mixture, sand and loam, holds moisture well and is easy to work.

Most soils are slightly alkaline to litmus paper. Most plants grow best in a slightly alkaline soil, but some do best in an acid soil. It is important, therefore, to test the soil to determine if it is acid or alkaline. You will be interested to learn how to test your soil. Or you may have your Farm Bureau test it for you.

PREPARING THE SOIL FOR THE SEEDS.—Any garden or farm soil should be fertilized and supplied with humus for each succeeding crop. Sometimes the humus is supplied by planting rye, or other leafy crops, the previous fall and plowing them under in the spring. Crops sown in the fall for plowing under in spring are called *green cover crops*. The green material dies and adds organic matter to the soil. Plant minerals are supplied by adding farm manure and other fertilizers. The farm manure also adds to the humus supply.

Many gardeners make use of a *compost* pile. A compost pile is made up of vegetable tops, fallen leaves, and leafy parts of other healthy plants. The pile is gradually built up with thin layers of plant material, lime, and fertilizer. The vegetable matter decomposes and forms valuable humus and mineral material. It can be used as fertilizer the following spring. Diseased parts of plants should never be added to the compost. They should be burned.

After proper fertilization, including the addition of lime if the soil is too acid, the soil is plowed or spaded. Then it is harrowed. This is done about two weeks before the planting time.

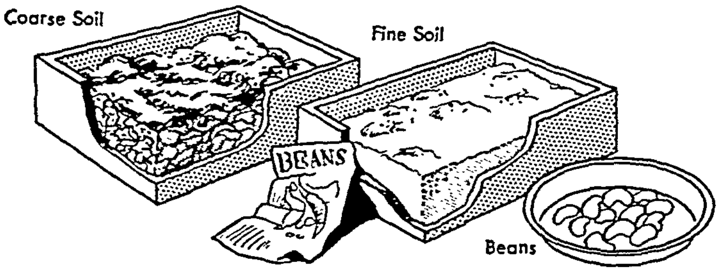
For many years farmers have plowed the soil deeply. Recent experiments by soil scientists show that in some cases it may be better not to plow so deeply. In much of the wheat belt, for example, the plowing consists of stirring only the upper few inches of soil.

Just before planting, the soil is again harrowed thoroughly to produce a finely divided soil at the surface. The time between the plowing and final harrowing allows the weeds to start from seeds left over from fall. The final harrowing destroys these weeds and is a large factor in the prevention of weeds later on. Thus harrowing is of great importance to the gardener.

The smaller the seed the finer the soil it needs for early growth. Small seeds are barely covered with fine soil. More-

EXPERIMENT 37

Will seeds grow better in soil that is finely grained than in unbroken soil?



In working this experiment, remember that it is on such a small scale as compared with a real garden that results are easy to obtain. If you can carry out this experiment in your garden, so much the better.

WHAT TO USE.—Two boxes of equal size; two samples of the same soil, one finely mixed and the other left in coarse lumps; and a package of seeds—peas or beans—that have been soaked overnight.

WHAT TO DO.—Fill the boxes, one with lump soil and the other with fine soil. Plant the seeds according to directions on the package, but do *not break up the lumps. Water both boxes alike when you have planted* the seeds.

Set the boxes in a warm place and observe and record the growth results from day to day.

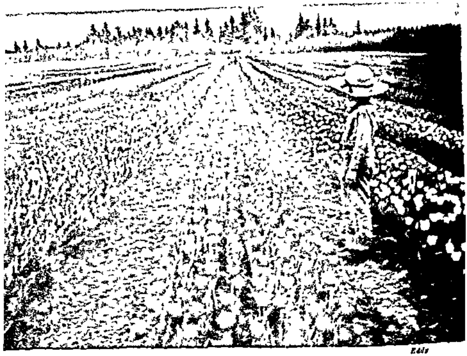
Examine the soil each day to see which appears to dry out faster.

WHAT HAPPENS.—Do the seeds grow alike in both boxes? Does the soil dry out faster in one box than in the other? Why?

CONCLUSION.—Which method of preparing the soil promotes the better growth? Explain.

APPLICATION.—The smaller the seeds the finer the soil should be. Why?

over soil must fit snugly about the seed and tiny new root that forms so that the rootlet can obtain the water and minerals it needs. If the soil is too coarse, the seeds may dry out and fail to grow. Seeds must have water to grow. Try Experiment 37 to find out for yourself how the character of the soil affects the growth of seeds.



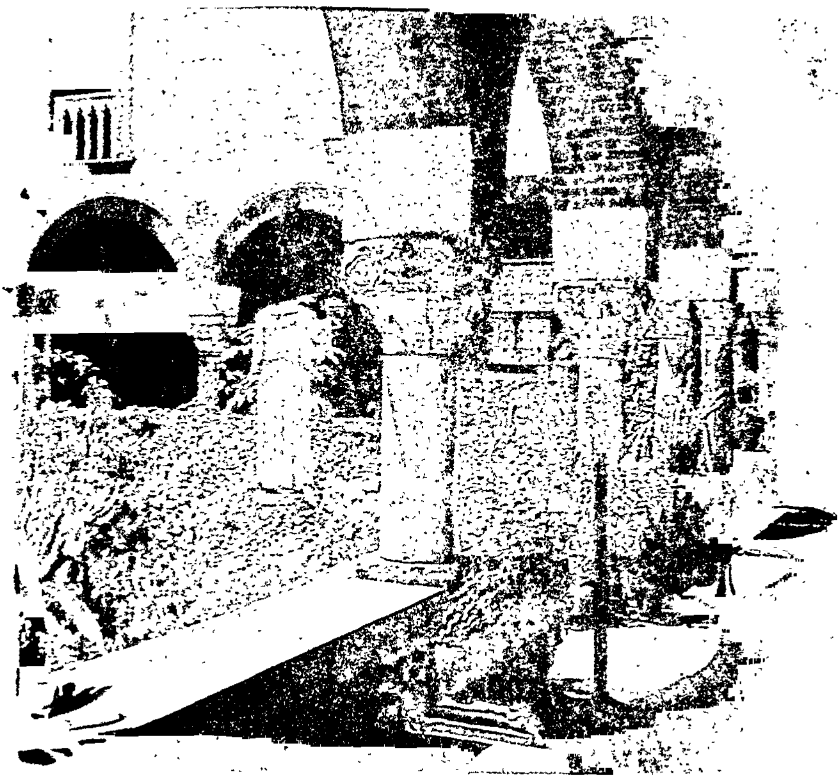
Tulip Time.—Most gardeners raise their tulips from bulbs. Nurseries develop new types of tulips from seeds. The seeds are planted, and over a period of several years the bulbs develop. Each bulb will always produce a tulip of the same color and shape. Thus the nursery can send to the gardener just the colors he wants.

GENERAL PROBLEM 2

Why Have a Planting Plan?

A Plan for Your Garden.—The most successful garden is the one planned long ahead. This is true whether you plan for a vegetable garden, a flower garden, or a complete landscaping project. The successful farmer must plan his crops several years in advance. He who waits until planting time to plan his garden is likely to be disappointed. In fact, a garden is a year-round affair and not just a spring and summer interest.

If your plans for landscaping your grounds are not complete, you should at least select your garden plot in the fall. See that the weeds are removed before the season closes and that green cover crops are sown if needed.



Litvin

A Formal Garden.—Some people prefer informal gardens or woodland gardens. Others like the formal type such as this one at the Gardner Museum in Boston. No matter what type of garden you want, it should have a plan and it must be cared for.

For the spring planting, January is not too early to begin your plans. (Refer to your Observers' Club Calendar for suggestions.) Is it to be a flower garden, a vegetable garden, or both? Are there shrubs to be placed about the home? If it is to be a flower garden, are the flowers to be *annuals* or *perennials?* Annuals are plants that grow flowers and seeds the first year, after which the parent plant dies. Perennials bear flowers and seeds each year for a number of years.

FIELD RESEARCH

Send for seed and plant catalogs from reliable seed houses to help you decide what varieties of seed and plants you wish.

In planning your garden you must have in mind how long a time it takes different plants to reach their full growth. Some small vegetables mature quickly. Their place in the garden may be replanted with second sowings to the same or some other seed.

If flowers are in your plan, you should try to have a succession of blooms from early spring to late fall. Your perennials and shrubs must be given a permanent place in your scheme. Other planting must be made accordingly, keeping in mind color, time of flowering, and height.

FIELD RESEARCH

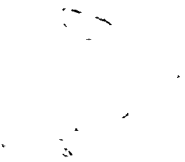
Visit commercial garden shows or plant nurseries for suggestions or arrangement and varieties of shrubs and flowering plants.

In deciding what to plant, it is necessary to consider the size of your garden plot and where each plant is to be placed. Therefore, you should measure your plot and draw a plan of it to scale.

Catalogs and garden books will tell you how far apart rows of vegetables should be. They also tell how much room must be given for each of the plants or shrubs you select. You can then draw the rows on your paper plan and can mark locations

Healthy Seeds—Seeds come in many different sizes and shapes. On the left, the smaller seeds are pansies and the others, sunflowers. On the right is a group of ordinary lawn seeds and their husks. All these seeds, of course, are magnified.

Ewing Galloway



for individual plants. Do not forget to keep in mind the succession of vegetables and flowers.

The successful farmer plans his crops as carefully as the flower or vegetable grower. The farmer must plan to raise feed for his stock as well as crops to sell. The soil in one part of the farm may be better suited to one crop than another. It should be tested for acidity or alkalinity. The fields should be plowed and cultivated so as to conserve the soil. On hilly ground different crops need to be planted in strips following the contours of the hills, rather than up and down. This is called *contour* planting and prevents erosion.

FIELD RESEARCH

Study the frost maps on page 108 to get an idea of the latest killing frost in the spring and the earliest killing frost in the fall. The number of days between them is your safe growing season for plants that are killed by frosts. The average temperature for your locality in spring and fall is also useful data.

MAKING THE PLAN.—Before you lay out a paper plan for landscaping or a garden, visit some well-planned landscaping projects. Then study books and current garden magazines for

Hauling Fertilizer.—Modern machinery makes the farmer's job easier. These farmers are using a truck to carry bags of fertilizer to the fields for spreading where it is needed.

Courtesy Automobile Manufacturers' Association

suggestions and instruction. If possible, talk with landscape architects, who know the value of planning.

Then on a large sheet of paper mark in the shape, size, and location of your buildings, existing trees, shrubs, gardens, roads, and paths. With this as a basis, you can proceed to develop a complete garden plan.

Your plan should be laid out with a central line of development If your grounds are not level, it may be necessary to include a profile plan The profile will show where you must dig out or fill in to give the grades or slopes the best effect.

The following features are usually included in a landscaping plan. Each should receive careful consideration.

(1) Drives and walks.

(2) Foundation planting about building. This consists of evergreens and shrubs to bring out architectural features of the building, hide walls, and give a tie-up between the building and ground.

(3) Border planting This is planting along the drives and edges of the plot Trees and shrubs are useful here in shutting off the garden from public view and forming backgrounds.

(4) Lawns and lawn planting. These are grass and special trees and shrubs.

(5) Hedges, fences, and walls to inclose formal or semi-formal gardens

(6) Rock gardens and pool

(7) Arbors, lawn furniture, and the like for decorative effects.

(8) Location, shape, and sizes of perennial and annual flower beds, rose garden, and vegetable garden.

(9) A planting list Consider the hardiness of trees and shrubs required by your local climate. Consider also height, foliage, colors in spring, summer, and autumn. A complete plan, even though only small parts of it are planted each season, is better than "hit-and-miss" planting. Moreover, there is great pleasure in seeing the complete garden take form gradually

GARDEN TOOLS.—"A workman is known by his tools." The good gardener buys good garden tools and then takes good care of them. Each time when you have finished using your garden tools, wipe them clean before putting them away. In addition to tools for working the soil, you will need simple dusting or spraying equipment to aid in your fight against garden pests.

GENERAL PROBLEM 3

How and When May Seeds Be Planted?

SEEDS.—The following clipping from a newspaper tells its own story:

> "Taking the gamble out of agriculture" is a proposition that works for everyone's welfare. And the fundamental gamble in farming is the seed sown, whether you are working under glass or on a thousand-acre ranch. Think of the nurseryman who buys 20,000 dollars' worth of seed from abroad, plants them, waits and works a year, and finds out that most of the seed had no life. This has really happened.[1]

Seeds that will not germinate properly or are diseased waste time, land, and money for you. Seeds that germinate but grow inferior products are also to be avoided. You can test your seeds for germinating quality if you will follow the directions of Experiment 38.

Plants are liable to disease the same as people. The scientific grower tries to prevent his plants from getting sick. One way to do this is to use only healthy seeds. Often seeds are treated with certain chemicals that destroy disease germs or molds that may be on the seed.

PARTS OF A SEED.—Your investigation of the germination of seeds raises the question as to the parts of a seed and their uses.

The outer skin protects the seed during its resting period, keeping it from drying out. The two bulky parts (some seeds have only one such part) are the *cotyledons*. They supply food to the little plant until it develops roots and leaves. Then it is able to manufacture its own food.

When a seed is planted it absorbs water from the soil. The cotyledons swell and break open the outer covering. More moisture enters and the little plant, called the *embryo*, begins to grow.

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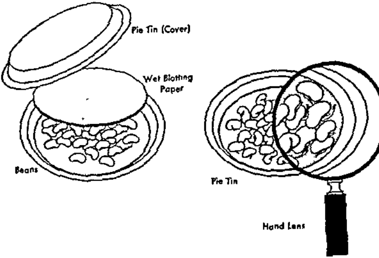
[1]*Democrat and Chronicle*, Rochester, N.Y.

EXPERIMENT 38

What per cent of my garden seeds will germinate?



You have already discovered that a seed must have water and warmth to germinate, that is, to begin to grow. This experiment will help you discover whether cheap seeds are really inexpensive

WHAT TO USE.—Seeds to be tested (if possible, secure cheap packages of seeds and expensive seeds for comparison); wet blotting paper; pie tins (two for each sample of seeds to be tested); and a hand lens.

WHAT TO DO.—1. Thoroughly wet a piece of blotting paper and place it in one of the pie tins. Count out 50 seeds of a sample to be tested and cover them with a second piece of wet blotter, and then with a pie tin, but not air-tight.

2 Repeat with as many samples as you wish to test, and place the tins in a warm place Keep the blotters moist but not standing in water.

3 After 48 hours examine the seeds of each sample, and count the number that have started to grow Re-cover the seeds and examine them again after another 24 hours. Again count and record the number that have germinated.

4 Examine some of the seeds that did not germinate to observe whether they appear to have been well-formed seeds

In each sample calculate the per cent of seeds that germinate

WHAT HAPPENS.—3 How many seeds of each sample germinated?

4. Describe the appearance of the seeds that did not germinate

CONCLUSION.—In each sample of seeds what per cent germinated?

Is the per cent of germination high enough to warrant planting the other seeds of the sample?

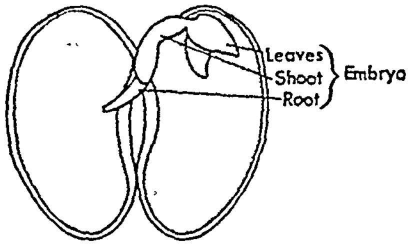
Is it worth while to test seeds before planting them?

APPLICATION.—Does it pay to buy cheap seeds?

FIELD RESEARCH

Soak a few seeds of beans and peas overnight. With a needle remove the outer skin, if the seed has one. (Refer to the diagram below for names of parts.) Carefully separate the parts and, using a hand lens, look for the little plant.

The embryo has one or more leaflets and a little stem. The little stem grows, the leaves grow, and soon a tiny root appears. All this time the new little plant gets its food from the cotyledons which begin to shrink. After a while the cotyledons are, in the case of beans and some other seeds, raised out of the soil. Soon two more green leaves appear. As the stem gets longer and the root grows bigger, more leaves appear. As soon as green leaves appear the little plant becomes self-supporting. The cotyledons wither and fall off. The green leaves, with water from the roots, carbon dioxide from the air, and energy from the sun, make their own food. It is a miracle of nature.



Parts of a Seed.—The two large gray parts shown here are the cotyledons. They are a part of the seed, but not a part of the embryo. Can you explain that?

STARTING SEEDS IN FLATS.—In localities where the growing season is short, seeds are often started in flats, shallow boxes 3 to 6 inches deep. Filled with moist sandy soil, they are used for starting seeds several weeks before planting time outdoors. The exact time for starting seeds depends upon the plants and the locality. You may obtain accurate information from the

Radish Seeds.—This picture shows the first sprouts of the seeds, twenty-four hours after planting. These are the first tiny roots that take in water for the growth of the plants. Here the magic of life and growth has begun.

local seed store, your school agriculture teacher, or the State College of Agriculture

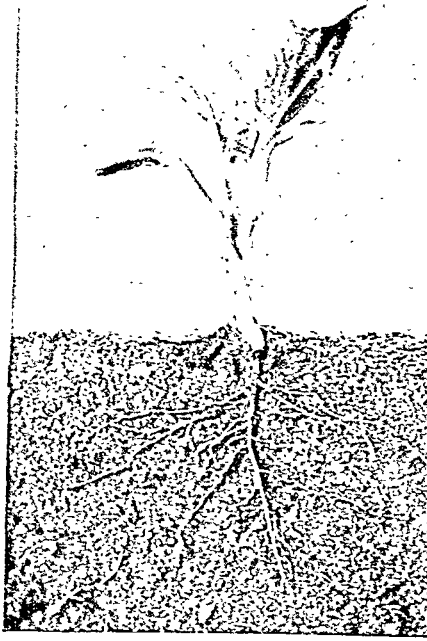
Especially in places where the growing season is short, better results follow if seeds are started in *hotbeds* or *cold frames*. Not only many flower seeds, but vegetable seeds such as cabbage, tomato, and melons are profitably started in this way.

FIELD RESEARCH

Make a trip to a commercial greenhouse early in February to discover how the workmen are preparing for early vegetable and flower plants Then prepare a flat for early seed planting. Consult your Observers' Club Calendar for suggestions. The seeds should be covered with firmly packed, sandy soil to a depth of about three times the length of the seed Keep the flats in a fairly cool room. A temperature of about 60° F. is satisfactory. Moisten the soil a little each day, but do not soak it

HOTBEDS AND COLD FRAMES.—If you wish to raise early vegetables and flowers, you will have to learn to use hotbeds


Black Star

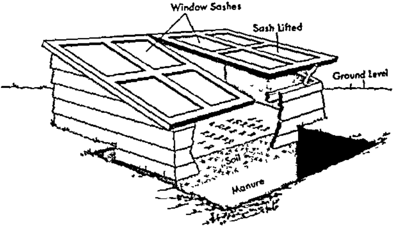

Black Star

Growing Up.—On the left the roots of the radish plant are growing stronger, pushing on through the soil. Note the two cotyledons of the radish. They supply it with nourishment during these early stages of growth. On the right the leaves have developed, so that the plant is now able to manufacture its own food.

and cold frames. Both of these devices are boxes, with sides 12 inches to 24 inches high. They are set part way down in the soil and covered with frames with glass in them. The frames are adjustable to permit proper ventilation of the bed. The glass allows the radiant energy of the sun to go through and warm the soil underneath. At night the glass largely prevents the loss of heat from the soil. For these reasons, the soil under glass will be warm enough to allow plants to grow long before the soil outside would permit the growth.

The hotbed is heated not only by the sun, but also by gradual decay (oxidation) of farm manure. It is also possible to heat the bed with electricity. Of course with electricity the temperatures can be controlled much more accurately.

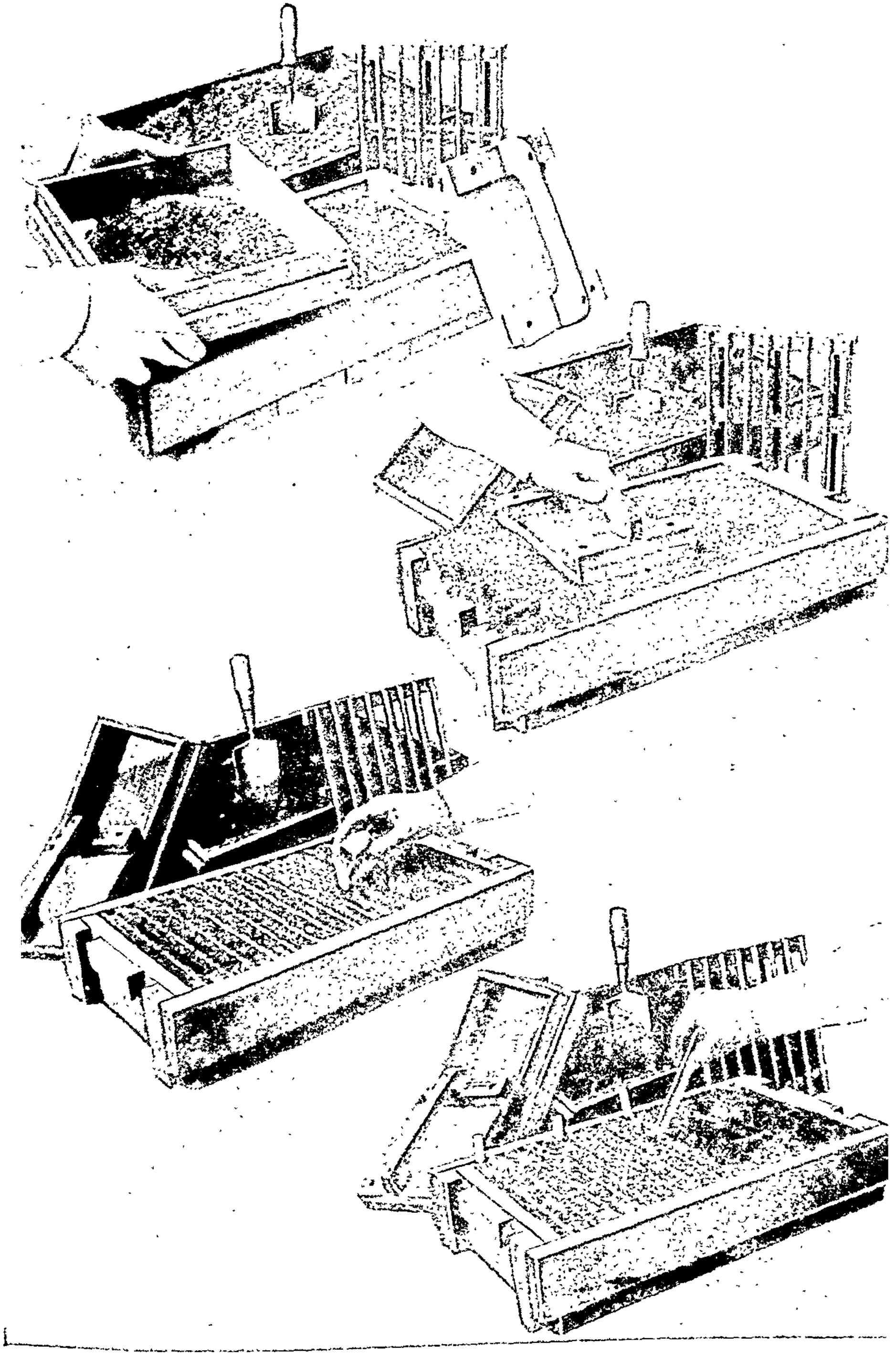
To make an ordinary hotbed, soil is removed from within the box. A thick layer, one to two feet deep, of unrotted manure is put in. This is then covered with four to five inches of rich garden soil. This much is better done late in the fall. In the spring, the manure rots and gives off considerable heat to the soil. Therefore, with the top covered with glass, the soil warms very early. When the soil begins to heat, it will heat rapidly, and seeds should not be planted until the temperature has dropped to below 100° F.



A Hotbed—An important part of the hotbed is the layer of manure. Explain how the manure helps keep the soil inside warm. Does the glass above help? Why must the hotbed be ventilated? What is the difference between a hotbed and a cold frame?

A cold frame is like a hotbed, except that it has no manure or artificial heat.

As the spring advances, care must be taken not to let the plants burn from overheating. The glass must be opened for a short time each warm day and, finally, at night as well. Cold frames and hotbeds must be ventilated because plants must have fresh air. The bed, too, must be kept properly watered. (Refer to your Observers' Club Calendar for dates of starting seeds and for transplanting. And, of course, allowance must be made depending upon what part of the country you live in.) For detailed directions concerning the use of cold frames, hotbeds, and greenhouses you should refer to special books on those topics.



The Preparation of a Seed Box.—At top the soil is being sifted, then it is smoothed. The third step is spreading the seeds, and finally they are covered.

Part of the joy of gardening is to raise at least a portion of your own seed for the next year. You can thus study the whole life history of a generation of vegetables and flowers. Let some especially fine flowers go to seed. When they are ripe, gather the seed, and place in carefully labeled packages for storage until next spring or planting time.

LIBRARY RESEARCH

Read about the work of Burbank, and perhaps you may do a little experimenting with plant breeding and improvement.

TRANSPLANTING.—The seeds may be planted too close together in the flat for proper growth after a few days. Therefore, when the seedlings have grown their second leaf, they should be transplanted into other flats, or outdoors where they will be given more room.

The soil for transplanting should be a rich loam soil. You know that a seed contains its own food in the beginning. As soon as the second leaf appears the soil must furnish food-building materials to the plant.

TRANSPLANTING TREES AND SHRUBS.—Deciduous trees (those that lose their leaves in the fall) are best transplanted in the early spring or late fall. They are then in a resting condition and so are best able to stand the shock of a change. Roots and branches should be pruned, and the plant set in a hole and thoroughly watered. The soil must be packed very hard about the roots. The plant should be supported against the wind by guy strings.

Nursery stock obtained in the fall is usually fresh-dug stock. Spring stock is usually stock that was dug in the fall and held in cold storage until spring. Some spring stock is *fresh-dug*.

Evergreens also may be transplanted in the early fall or spring. Fall transplantings must have time to make some root growth before freezing weather sets in. Therefore they should be kept well watered.

OUTDOOR SEED PLANTING.—Seeds are usually planted in rows or hills. Rules for depth of planting are the same as for planting in flats. When the seedlings planted out of doors have grown their second leaf, they should be thinned to give proper room for development. After thinning, the soil should be kept cultivated and weeded.

FIELD RESEARCH

For transplanting prepare a flat with moist, rich soil. Small pots may be used instead of flats. The night before you wish to transplant the seedlings, they should be well watered.

With a knife or trowel carefully take up a small number of seedlings. Select those that seem sturdiest and set each one in a small hole in the soil made with the finger or a small stick, and pack the soil firmly about the root. The seedlings should be set in the soil at about the same depth at which they have been growing. They should be set two inches or more apart to give room for proper development.

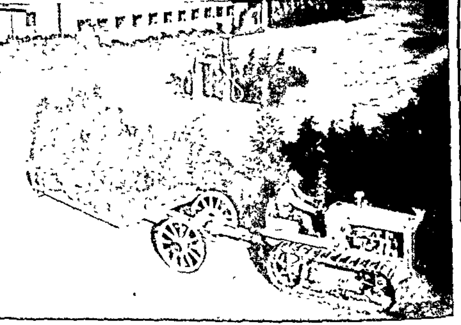
The plants should be watered daily and placed in sunshine, if this is practicable. If located near a window, turn the boxes about, to keep the plants growing straight. As the plants grow larger they should be gradually accustomed to outdoor air. They can be again transplanted to the outdoor garden as soon as the danger of frosts is over. When ready for transplanting to the garden, they should be thoroughly watered the night before.

The soil about the roots should be taken up with the plant. When first set out, the plants should be protected against cold and against too-hot sunshine.

In your garden plan you have provided for successive plantings. You should follow your plan closely.

GROWING NEW PLANTS WITHOUT SEEDS.—Many plants can be started by *cutting* or *slipping* off a branch and letting it take root in water or moist sand. In fact, this is a very valuable method of propagating various plants and shrubs. Geraniums and different types of ivies are often started by this method.

Some plants, like tulips, grow from *bulbs*. These plants form new growths or separate bulbs on the old ones each year. After the blossoms have wilted and their leaves have turned yellow, they may be taken up. The bulbs may be separated, and new plants grown from each one. The food stored in the bulb enables it to grow the next season. It may not blossom until the following year.



Transplanting Evergreens.—These ornamental evergreens are being hauled by "caterpillar" tractor to be put on display in the nursery. Note the burlap bags in which the roots of the trees are protected. Scientific transplanting of trees is big business now. This particular nursery supplies evergreen trees and shrubs all over the world. At what time of year might this picture have been taken?

Some bulbs are often forced for house-flowering in the winter. They should be placed in soil in pots and kept in a dark basement for a few weeks (to enable the roots to start). Then they should be brought into the warm air for forcing. Refer to your Observers' Club Calendar.

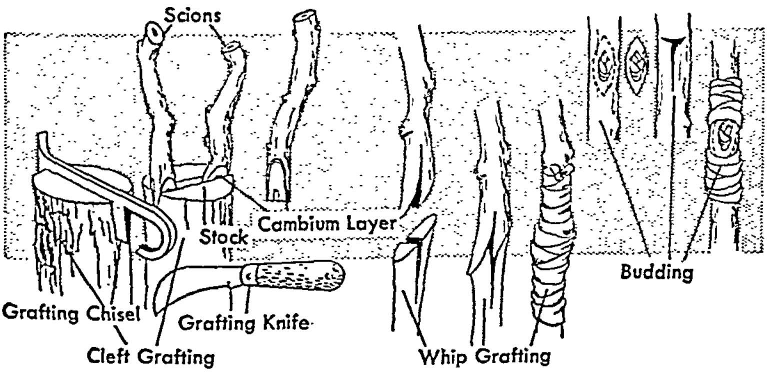
Grafting and *budding* are methods used to propagate many trees and shrubs By this method a small branch or bud of one tree is planted in another tree This is done by opening the bark and inserting the branch or bud into contact with the growing layer (*cambium*) of the plant being grafted. If you want to do this kind of plant propagation, you will need to go to some greenhouse or nursery for help. Many roses and fruit trees are budded plants. Even shade trees are often budded to secure certain characteristics of growth. By such special methods of propagation, it is possible to obtain growing and bearing plants faster than from seeds.

FIELD RESEARCH

If you want to raise some plants from cuttings, you must know what plant to use (see the Observers' Club Calendar) and where to make the cut. Roots can be made to grow from the place where the buds grow on the stem—called a *node*. To make a cutting of a geranium, begonia, or any non-woody plant, use a sharp knife and cut off the end of a stem just below a node. There should be only one or two leaves about the node.

Place the node end rather deep in the moist sand—not too fine, for the little stem needs air as well as moisture. Moisture, air, and water are needed to start root growth. After the new plant is well rooted it should be transplanted to a small pot. The dirt in this pot should be good soil, with plant food in it. The clean sand used in the first place does not contain much plant food.

There are substances called *hormones* which scientists have discovered will aid or promote root growth. You may wish to investigate and use some of these hormones. Later the cutting may be transplanted to a larger pot for the indoor garden or out of doors.



Grafting.—These are methods of making part of one plant grow on the root part of another. Many fruit trees and shade trees are grafted. The young stems are grafted onto a hardy root stock. Did you know that orange trees are often grafted onto lemon roots? Can you think of any reason why this is done?

How Should the Garden Be Cared For?

A CONTINUING JOB —Making a garden plan, preparing the soil, and planting the seed are the first steps in gardening. All the work involved in doing these will be wasted unless the garden is cared for during the growing season. One of the most important jobs of the gardener or the farmer is cultivating the soil.

WHY CULTIVATE THE SOIL?—Anyone who lives on a farm or just has a city garden knows that cultivation helps keep the soil from drying out. What does cultivation do to preserve the soil water?

For years it was thought that the soil water rose to the surface through tiny tube-like spaces in the soil called *capillaries*. Once at the surface of the soil, it evaporated. The rise of the water through the spaces in the soil was explained as capillary action—a sort of pumping action that causes water to rise in fine hair-like tubes It was believed that cultivation broke up the capillary tubes and thus prevented the soil water from rising.

This explanation is probably still true where the water table is within ten feet from the surface. But soil water experiments indicate that when the water table is below ten feet from the surface, very little if any water rises by capillary action.

How then does cultivation preserve soil water? Scientists have found that plants evaporate great quantities of water. They evaporate much more water than the surface of the soil Thus the best way to preserve soil water seems to be to remove all unnecessary plants. *Cultivation is important in preventing loss of soil water because it removes weeds which take water from the soil.*

Sometimes a straw *mulch* is spread about a plant to help conserve the moisture in the soil. A mulch is loose material placed in the soil. It preserves soil water by shading the soil from the sun's rays. In this way it reduces the amount of water evaporated directly from the soil. More important, the mulch covers the ground so thoroughly that weeds are unable

Ewing Galloway   Courtesy J. J. Case Co.

Cultivating the Soil.—The home gardener on the left is cultivating the soil of his small corn field. The hand cultivator he uses is small and simple, but it serves to stir the soil and cut out weeds. At the right a great field of corn is cultivated with a tractor. This piece of machinery saves time by cultivating two rows at once.

to get started. Mulching papers or peat moss as well as straw may be used for a mulch.

Working the soil by spading, hoeing, and raking serves also to mix air with the soil. Bacteria at work in the soil need the oxygen of the air. The mixing of the top soil with air prevents the soil from becoming *sour* or *acid*. It also removes weeds, and this we know is most important in conserving the soil water.

Hoeing is necessary also to heap the soil about the roots of plants as in hilling potatoes and corn. This helps to hold the plants in place and to keep the light from the roots. If potatoes, which are really parts of the stem, are left uncovered in sunshine, they turn green and taste sweet.

In spite of efforts to conserve soil water, much of it is lost by evaporation from the soil and from the leaves of crops. Hence, unless the water table is near the surface of the soil, frequent rains or artificial watering are necessary. *Irrigation,* used to supply water in dry regions, has made the Central Valley of California one of the richest agricultural areas in the world.

How Should the Garden Be Cared For?

A CONTINUING JOB.—Making a garden plan, preparing the soil, and planting the seed are the first steps in gardening. All the work involved in doing these will be wasted unless the garden is cared for during the growing season. One of the most important jobs of the gardener or the farmer is cultivating the soil.

WHY CULTIVATE THE SOIL?—Anyone who lives on a farm or just has a city garden knows that cultivation helps keep the soil from drying out. What does cultivation do to preserve the soil water?

For years it was thought that the soil water rose to the surface through tiny tube-like spaces in the soil called *capillaries*. Once at the surface of the soil, it evaporated. The rise of the water through the spaces in the soil was explained as capillary action—a sort of pumping action that causes water to rise in fine hair-like tubes. It was believed that cultivation broke up the capillary tubes and thus prevented the soil water from rising.

This explanation is probably still true where the water table is within ten feet from the surface. But soil water experiments indicate that when the water table is below ten feet from the surface, very little if any water rises by capillary action.

How then does cultivation preserve soil water? Scientists have found that plants evaporate great quantities of water. They evaporate much more water than the surface of the soil. Thus the best way to preserve soil water seems to be to remove all unnecessary plants. *Cultivation is important in preventing loss of soil water because it removes weeds which take water from the soil.*

Sometimes a straw *mulch* is spread about a plant to help conserve the moisture in the soil. A mulch is loose material placed in the soil. It preserves soil water by shading the soil from the sun's rays. In this way it reduces the amount of water evaporated directly from the soil. More important, the mulch covers the ground so thoroughly that weeds are unable

Ewing Galloway   Courtesy J. J. Case Co.

Cultivating the Soil.—The home gardener on the left is cultivating the soil of his small corn field. The hand cultivator he uses is small and simple, but it serves to stir the soil and cut out weeds. At the right a great field of corn is cultivated with a tractor. This piece of machinery saves time by cultivating two rows at once.

to get started. Mulching papers or peat moss as well as straw may be used for a mulch.

Working the soil by spading, hoeing, and raking serves also to mix air with the soil. Bacteria at work in the soil need the oxygen of the air. The mixing of the top soil with air prevents the soil from becoming *sour* or *acid*. It also removes weeds, and this we know is most important in conserving the soil water.

Hoeing is necessary also to heap the soil about the roots of plants as in hilling potatoes and corn. This helps to hold the plants in place and to keep the light from the roots. If potatoes, which are really parts of the stem, are left uncovered in sunshine, they turn green and taste sweet.

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In locations where irrigation is impossible, the farmer must combat a long drought by cultivating. This prevents weeds from using the little water remaining in the soil.

As we learned earlier, under certain conditions rain may be "made" by *seeding* clouds. Tiny bits of dry ice or other chemicals have been used as particles for moisture to condense on. Whether rainmaking will become a practical means of supplying water for farming is still a question. (See pictures on page 511.)

The home gardener who can water during a drought is more fortunate. He should water infrequently, but for long periods at a time This allows the water to sink deep into the soil. Even so, the plot should be kept free from weeds in order to save the moisture in the soil.

ROTATION OF FARM AND GARDEN CROPS.—Every plant takes certain minerals from the soil, such as phosphorus, calcium, and nitrogen compounds Some plants require large amounts of nitrogen compounds. They leave the soil "poor" in nitrogen compounds. In the same way, other plants take large amounts of certain minerals. It is a good plan, therefore, not to plant the same crop year after year. By changing the crops, the soil is given a chance to build up its supply of minerals naturally. This plan of changing crops is called *crop rotation.*

With farm crops, a three-year or four-year rotation is common In the south, a cotton crop may be followed by oats and then by corn In the north, root crops, cabbages, and corn may be followed by oats, barley, or wheat. With the wheat may be sown timothy and clover for cropping the following season. Or the wheat may be followed by alfalfa The exact rotation depends on whether the farm is a dairy farm or a grain farm.

Rotation of crops gives the soil a chance to recover minerals taken from it by the crops. Also, insects and diseases associated with one crop are likely to disappear while other crops are being raised. Of course, intensive farming as practiced in some parts of the United States does not use crop rotation. In such cases, a chemical analysis of the soil is made The proper plant foods and minerals are added in correct amounts. Some crops require slightly acid soil, others neutral or alkaline soils. Certain plant diseases thrive in acid soils and not in neutral or alkaline soils. So farming becomes a science of soils and plants.

Fat Cattle.—In planning the rotation of farm crops, feed for the cattle must not be forgotten. The herd on this dairy farm is knee-deep in a sweet clover pasture. On dairy farms clover serves a double purpose. It helps enrich the soil and also supplies food for the farm animals.

Garden crops also should be rotated to some extent. However, soil deficiencies can be made up on small plots with special fertilizers. You should consult special books on gardening for details on this problem. In general, *leafy* plants should follow *root* plants. *Shallow root* plants should follow *deep root* growers.

NITROGEN-ADDING PLANTS.—Most crops take large quantities of nitrogen compounds from the soil. These compounds must be replaced or the soil grows very poor crops. You know that commercial fertilizers or farm manure may be used to supply nitrogen compounds. Fortunately, there are some plants which add nitrogen compounds to the soil on which they are grown.

Plants like clover, alfalfa, peanuts, and others contain bacteria in little swellings on their roots. These bacteria take nitrogen from the air and combine it with soil materials to make

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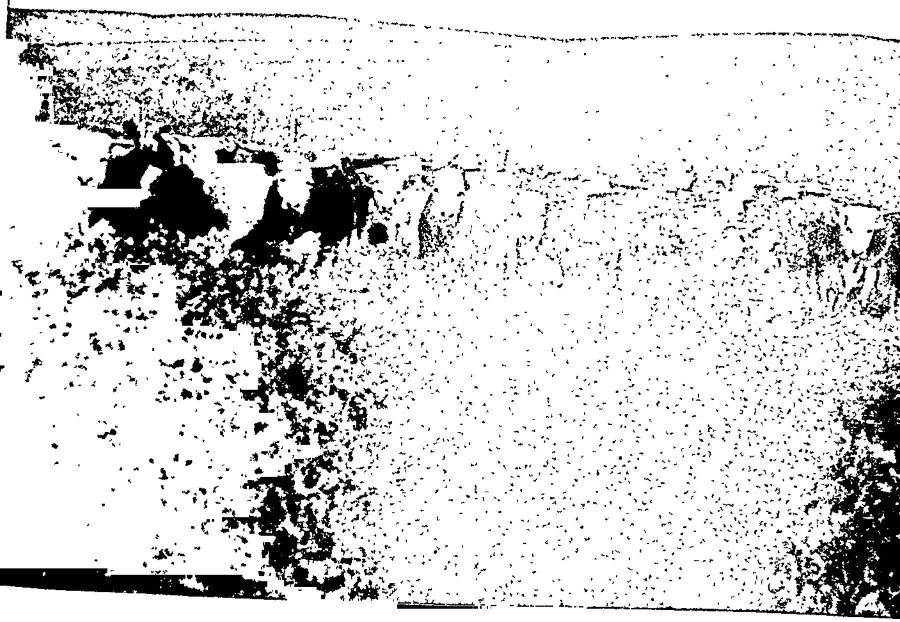

Fat Cattle.—In planning the rotation of farm crops, feed for the cattle must not be forgotten. The herd on this dairy farm is knee-deep in a sweet clover pasture. On dairy farms clover serves a double purpose. It helps enrich the soil and also supplies food for the farm animals.

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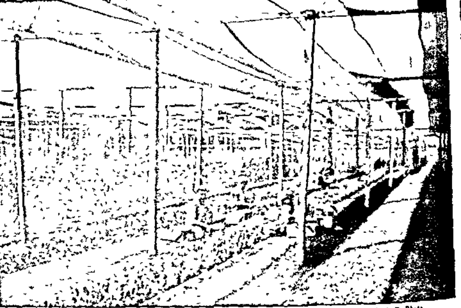

U S Army A A F Photo

Chemical Gardening.—It is not always necessary to have soil to grow crops Modern science has developed a method of raising plants with specially-treated water instead of soil. The plants are set in sand, gravel, or even cinders. Water, to which has been added minerals and other plant foods, is then supplied. Chemical gardening increases the yield and produces better plants. It is used extensively in greenhouses, but is too expensive for field crops, such as corn.

This picture illustrates a striking recent use of chemical gardening During World War II, the new method solved the problem of supplying our armed forces, stationed on barren islands, with green vegetables. The picture above shows one of these army chemical vegetable beds on Ascension Island in the South Atlantic. The netting above the beds provides shade for the tender, young plants.

nitrogen compounds Such plants actually add nitrogen to the soil when they are plowed under They leave the soil better than they found it. Farmers, therefore, usually have a nitrogen-adding plant in their crop rotation plan Of course, such a crop as alfalfa or clover may be grown in the same field for several years.

THINKING THINGS OVER.—The whole problem of growing plants involves a great deal of science. Therefore it is to be expected that successful gardening and farming will usually result from understanding and applying scientific principles. So important are these principles, that many colleges of agriculture have been established. Here young men and women train for scientific farming.

As we think back over this topic we realize the importance of soil. We realize that there is much involved in being a successful farmer or gardener. We realize the importance of knowing the properties of soil. We know about the importance of cultivation as a means of conserving soil water. We know the importance of good seed free from disease. We know the importance of crop rotation and nitrogen-adding plants. Do we remember all these points? If not, now is the time to turn back and make sure.

Key Words

annuals	evaporation	mulching
budding	fertilizer	node
bulbs	flats	organic matter
capillary action	germinate	perennials
cold frame	grafting	propagation
cotyledon	hotbed	seeds
crop rotation	humus	soil
cutting	irrigation	transplanting

Key Statements

1. Soil for successful gardening must be fertilized, supplied with humus, and tilled.

2. A garden, to be successful, must be well planned before it is planted.

3. Annuals produce seed the first year, after which they die. Perennials produce seeds each year for many years before dying.

4. Only seeds proved to be good by testing are worth planting.

5. A seed contains food material to support the growth of a new plant until the plant possesses roots and leaves to enable it to become self-supporting.

6. Hotbeds are heated by decomposing manure or by electric coils. The glass helps to retain the heat both from decomposition and from the sun.

7. A cold frame is kept warmer than outside air by the glass retaining the heat from the sun.

8 Plants of the family of clover, alfalfa, peas, and peanuts have nitrogen-fixing bacteria on their roots. When plowed under, these plants add nitrates to the soil.

9 Rotation of crops is necessary to help eliminate plant diseases and to conserve fertility of the soil

10. Garden tools will last longer and be more efficient in use if they are always put away clean

11 Water is conserved in the soil by cultivation and mulching. This prevents the growth of weeds which rob the soil of water

12 Irrigation is practiced where rain is infrequent during the growing season

13 For early planting, seeds may be started in boxes in the house or in hotbeds or cold frames.

14 Seeds should be planted out of doors only when the soil has become warm enough to insure germination.

15 Certain plants may be propagated by cuttings and others by budding or grafting. Those with bulbous roots may be propagated by separating the bulbs

16 Trees and shrubs may be transplanted successfully in spring or fall

Thought Questions

1 What is the reason for harrowing a field twice before planting?

2 Why may a field of alfalfa be cropped for several years without harm to the soil?

3 Of what value is grafting?

4 How does cultivation help preserve soil moisture?

5 Why will seeds grow better in finely worked soil?

6 Why are a garden plan and a planting calendar desirable?

7. Why are tested seeds preferable to ordinary seeds?

8 Account for the heat formed by the manure in a hotbed

9 Why must hotbeds and cold frames be ventilated?

10 In rotation of crops, why is it not desirable to follow one crop with plants of the same family?

11 Why will a potato in a hill turn green if exposed to sunlight?

12 Why is it possible to start seeds indoors before it is safe to plant them outdoors?

13 What conditions are required for successful transplanting?

Projects for Your Science Discovery Book

1. Write a story about the local soil in your community, telling how it was formed and from where it came.

2. *Make labeled drawings of a seed of a bean or pea.*

3. Make a trip to a near-by truck or flower garden and report the facts you discover about its garden plans and crops.

4. Record the planting date, date of appearance of seedlings, and other information of interest in connection with the seeds planted in the flats in your schoolroom.

5. Keep a record of your outdoor planting experiments.

6. Learn to recognize "stands" of wheat, oats, rye, barley, and buckwheat.

7. Find out what is meant by certified seed.

8. In your garden, keep a part of one row well worked, and neglect a similar part for two weeks. Compare the two rows as to moisture retained, growth of plants, and growth of weeds.

9. *Try placing black building paper between some of the rows of* your garden. What happens?

10. Start corn, wheat, and bean seedlings in the laboratory, and then transfer them to water solutions (see the Appendix) containing in one case all needed minerals, and in the other case no nitrogen, phosphorus, or calcium.

11. Organize a garden club and plan for landscaping a yard belonging to some one of your homes.

12. Try making green wood-cuttings.

13. With permission, try making a graft.

14. Insert blotting paper around the inside of a water tumbler. Keep about an inch of water in the bottom. Scatter a few radish seeds between the paper and the glass. Record your observations with a series of drawings.

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Vera and Henry Bradshaw

Friend or Enemy?—The common crow is generally disliked, for he eats seeds, sprouting corn, helpful insects, young chickens, and eggs. On the other hand crows also destroy many insect pests.

TOPIC XV

Farm and Garden Friends and Enemies

DO YOU KNOW—

1. What 2,4-D and DDT are?
2. How many lives an insect has?
3. How to protect your garden plants against diseases?
4. The common garden insect enemies in your region?
5. What makes a weed a weed?
6. Why birds should be protected?

GENERAL PROBLEM 1

How Can Weeds Be Controlled?

WHAT ARE WEEDS?—Is the dandelion a common weed where you live? Are *burdock* and *mustard* weeds in your locality? Or is *geranium* a weed in your neighborhood? Yes, it may surprise you to learn that the geranium is a weed in some places. In many parts of the country geraniums are cared for as garden flowers. Yet in parts of California wild geranium grows as a weed. What is a weed? How can the same kind of plant be a weed in some places and not a weed in other places?

We know that all plants need sunlight, water, and soil minerals. Any plant that grows and spreads rapidly and takes these things from more desirable plants is a weed. Thus we try to get rid of weeds so that our garden plants will have a better chance to grow.

WEED CONTROL.—Most weeds are hardy plants. They are not harmed by cold that kills other plants. Some can get along with very little moisture. Some have long tough roots. Most weeds produce many, many seeds. And their seeds germinate even under unfavorable conditions. For these reasons, weeds are difficult to control.

For example, the *dandelion* has a very tough root that is difficult to kill The stem can be broken off again and again and still new stems will grow The root can be broken and still it will survive The juice of the dandelion is bitter. Therefore animals will not eat the leaves. The flower head of the dandelion is really many single flowers bunched together. Hence there are many seeds from each flower head. When the seeds ripen they are equipped with parachutes so that they are spread widely by the wind. The seeds are hardy. If given any chance they will begin to grow.

FIELD RESEARCH

Collect some dandelion seeds and examine them to discover how the seed can be carried by the wind. Examine them with a magnifying glass, if you have one, to discover their shape and structure

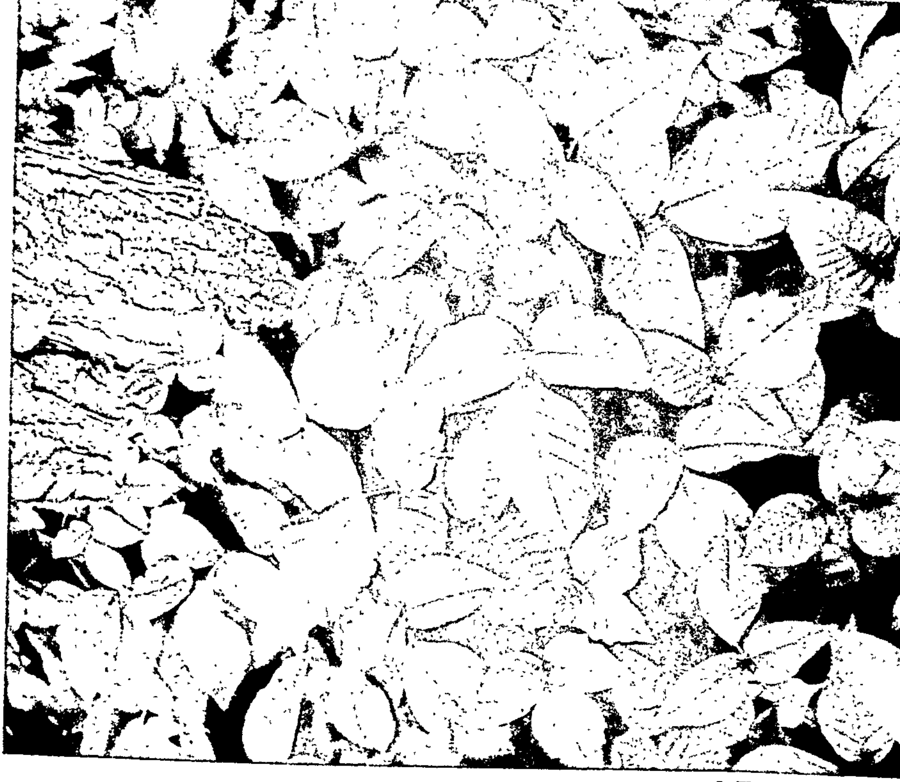
The common *mustard plant* with its small, yellow flower produces a large number of tiny seeds The seeds will survive the hardships of cold, wet, and dry spells that would harm other seeds The weed is best controlled by cutting down the plants before the seeds ripen.

Pigweed and *ragweed* also develop many hardy seeds and must be controlled by keeping them cut down before the seeds develop.

FIELD RESEARCH

Collect specimens of two or more common weeds that have seeds nearly ripe Take them to school and count the number of seeds contained in each plant.

Toadflax, burdock, milkweed, wild carrot, and *mullein* (or mullen) are weeds that cause much damage The crop losses from

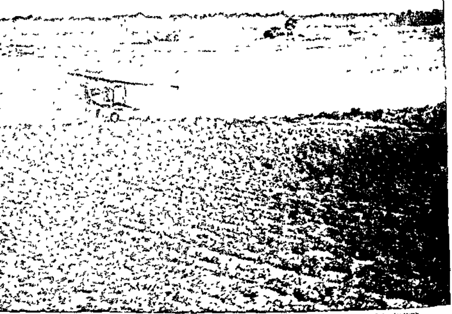


L. W. Brownell

Keep Off!—Poison ivy (above) and poison oak are so common in the United States that attempts to destroy them have not been too successful. It is dangerous even to stand too close to a fire of poison ivy. The smoke may contain enough oil to produce skin irritation.

weeds alone are estimated to total many millions of dollars every year. Nor is this the only trouble weeds cause. Some weeds, like *ragweed*, distribute pollen that cause some people trouble in breathing. This is called *hayfever*. Other weeds, like *poison ivy*, *poison oak*, and *poison sumac*, are poisonous to the skin. These weeds should be completely destroyed by chemical sprays now available. One such chemical is sold under the name of *ammate*.

How, then, can we control these hardy robbers among the plants? One way is to cut them down before they go to seed. This will not always work because often the weed sends up another stem which blossoms. Another way is to pull them out by the roots. This is the common way in gardens. It may be



U S Department of Agriculture

Dusting the Crop —A farmer can never rest in his battle against the insect enemies Here a cotton crop is being dusted by plane for boll weevil control The airplane is a valuable help in this battle, for it can cover much territory quickly and efficiently.

done with a hoe, a cultivator, or by hand weeding Another way of fighting weeds is to keep the soil well fertilized. Most weeds can live on less plant food than our garden plants. So they tend to appear in poor soil When there is plenty of plant food available, the garden plants may grow fast enough to crowd out the weeds. This is particularly true of weeds in a lawn.

FIELD RESEARCH

Start a collection of all the different weed seeds you can find At the same time find out how each seed is scattered or distributed.

The most recent way of fighting weeds is by use of chemical sprays. One of the most common is known as 2,4-D. It kills broad-leaf plants. It does not affect narrow-leaf plants, such as grains, grasses, onions, or lilies. Therefore 2,4-D is frequently used on lawns. It removes the broad-leaf weeds, but does not harm the narrow-leaf grass.

FIELD RESEARCH

Learn to identify the poisonous kinds of weeds that occur in your locality. Learn what to do if you or someone else is accidentally poisoned by any one of them. If you accidentally touch a poison plant like poison ivy, wash as soon as possible with plenty of soapsuds and water. Then see your doctor. If you walk through poison ivy, the poison may get on your shoes and stockings, and from them onto your hands. Watch out for poison ivy whenever you walk in the woods or wooded places. Look for the *sign of three leaves.* See that such weeds are destroyed in your community. Commercial sprays are now available which kill the plants.

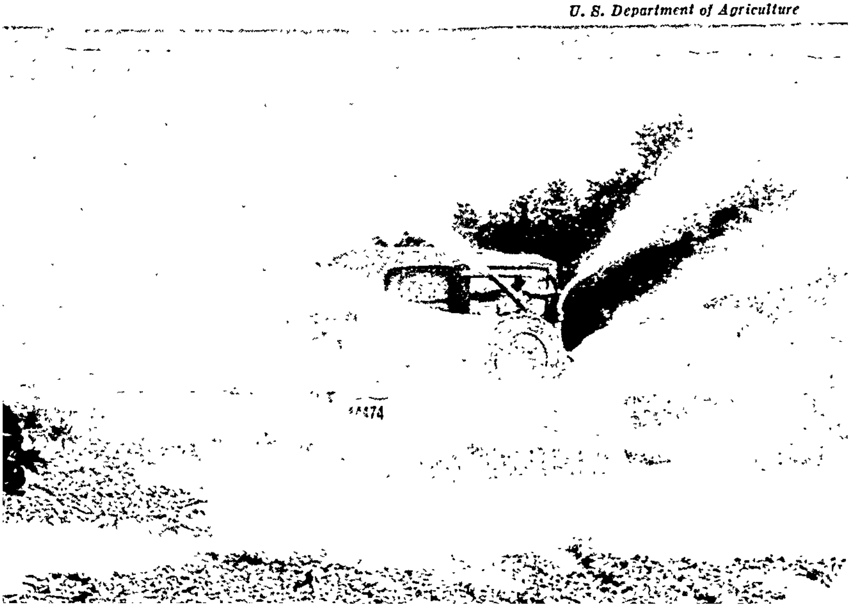
GENERAL PROBLEM 2

How Do Insects Harm the Garden?

Insect Pests of the Garden.—If insects could talk, it is likely that their slogan would be "War to the bitter end!" It is true that man's task of conquering and controlling the

Fighting on Land.—Here is still another method of continuing the struggle against the insect foe. This power duster sprays in many directions at once. Here it is being used in a citrus fruit grove to control the citrus rust mite.

U. S. Department of Agriculture



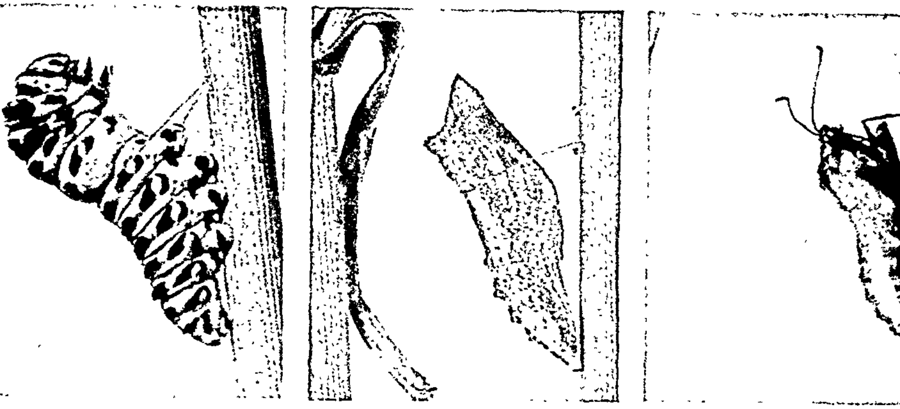
The Life Story of a Butterfly—These six pictures show various stages in the life of a swallowtail butterfly. In the first picture on the left, the female swallowtail is selecting a leaf on which to lay her egg. The second picture is a close-up of the egg, which is actually the size of a pin head. The third picture shows a caterpillar ten days after it has hatched from the egg. It is in this stage that damage to crops is done. The caterpillars eat tremendous amounts of leaves.

vast hordes of destructive insects is gigantic. Some scientists wonder what the outcome will be. Certain it is that to win the battle with the insects will require your cooperation and that of everyone else. With the aid of science and the natural enemies of harmful insects, there is hope. Many years ago it was said that the "damage wrought by insects every year nullifies the labor of a million men"[1] That statement is just as true today.

You have learned something of the rapid increase of flies, if they are not controlled. With many insects the rate of increase is much greater than that of the fly. While there are many different kinds and varieties of insects, your problem as a gardener will have to do with only a small number, some of them harmful and some useful. Certain insects attack the roots of young plants. Others suck the juice from the plant. Still other insects eat the leaves. You must know how insects live if you expect to control them.

ROOT, STEM, AND LEAF EATERS —One variety of insects is known as *root maggots*. They attack the roots of young turnips, radishes, cabbages, and onions.

[1] "The Greatest War of All Time Man Against the Insect," by M. K. Wisenhard, in *The American Magazine*, March, 1928.



H. B. Gray

End of the Story.—As the caterpillar eats, it grows larger and sheds its skin several times. Just before the last shedding, the caterpillar attaches itself to a leaf or stem by a knot of silk (first picture on left). Now it sheds its skin for the last time and becomes covered with a hard case. This is the pupa stage (second picture). The caterpillar eats nothing during this stage, but gradually changes into a butterfly. Finally, the hard case opens, and the butterfly wiggles out and flutters away.

The winged female (fly stage) lives through the winter and deposits her eggs in the soil very early in the spring. In a few days larvae hatch from the eggs. They begin at once to eat any tender roots that are available. At the age of three to four weeks, a larva changes into the pupa form, that is, it forms a case about itself. The pupa rests for two weeks. During its resting period the larva changes into the winged form and breaks from its case. The winged female deposits her eggs, and so a generation is completed. Each new batch of larvae feeds largely on roots of plants. Several generations of root maggots are produced each season and they are able, therefore, to do much damage.

The *cutworm* attacks plant stems, cutting off the stems of young tomato plants near the ground. A paper collar on each stem keeps the cutworms away from the plants.

The life history of the cutworm is similar to that of the root maggot. The cutworm in the winged stage has two pairs of wings. It is a moth, and flies usually at twilight or night. For control, collect and destroy the larvae or use poisoned bait in the soil before planting seeds.

A Swarm of Locusts—From Bible times up to the present, locusts have been among the farmer's deadliest enemies. This striking picture was taken in Africa. However, almost all farm land on the earth, except in cold countries, has been visited by locusts. The insects travel in huge swarms and when they descend on a field, they eat every green stalk and leaf before them

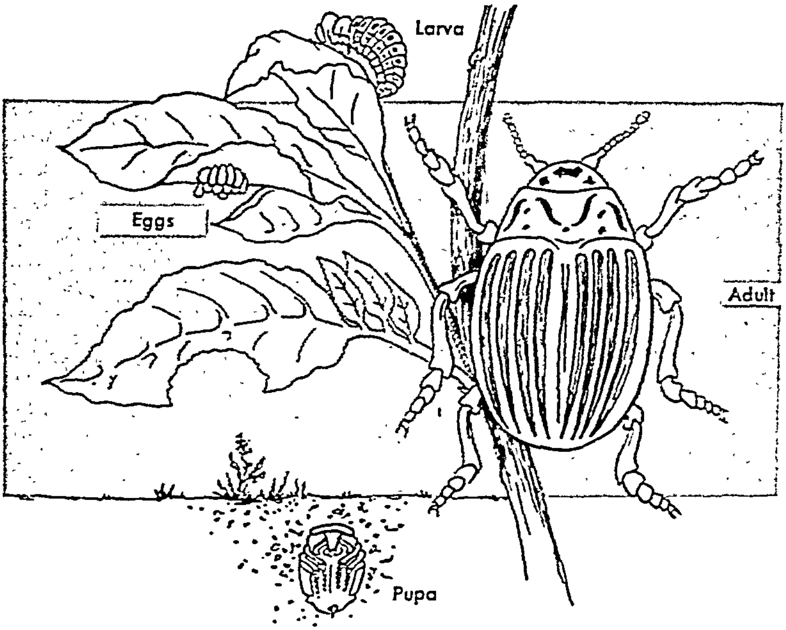
Some common leaf-eating insects are the *codling moth* (appleworm), *leaf rollers*, *gipsy moth*, *browntail moth*, and the *white-marked tussock moth* It is the larva (or caterpillar) stage which does the damage. Various *tent caterpillars* are destructive larvae that change into moths.

Insects which eat stems and leaves are called "biting" insects (See pictures on page 469.) They may be controlled by poisons sprayed or dusted on the plants. *Rotenone* and *arsenic of lead* are often used. As the larva eats the plant, it eats the poison. Rotenone is not harmful to people. Arsenic of lead is deadly poison. (See Appendix for various sprays and dusts)

FIELD RESEARCH

Select a moth and study its life history, damage it does, methods of control. (See Observers' Club Calendar for suggestions.)

BEETLES.—There are many varieties of beetles. Their life history is much like that of other insects. The egg hatches into a larva which is usually called a *grub*. Then comes the pupa or resting stage. Finally the adult insect appears with its hardened, armor-like wing covers.



The Potato Beetle from Egg to Adult.—Find the four stages of the beetle pictured here. At which stage does this insect do most damage to the plant? How does this harm the potatoes? How does the farmer protect his potato plants from the beetles?

Some beetles, like the potato beetle, feed on plant tissues and some feed on other insects. You can protect your potato patch from the potato beetle by hand-picking the beetles or by spraying the leaves with poison.[1] Study the diagram of the life history of the potato beetle above.

[1]See Appendix.

Crop Stealers.—On the left are six Japanese beetles. On the right is a corn borer. This insect attacks not only our corn crops, but also celery, potatoes, and tomatoes. One method of fighting the corn borer is to remove the stubble after the corn harvest. This is because the young of the corn borer live on the stubble during the winter. Another method is to introduce other insects whose young feed on the corn borer.

LIBRARY RESEARCH

Make a study of the Japanese beetle. Learn how it was introduced into this country, and when. How did it spread? What damage does it cause? How may it be controlled?

You will want to study pictures of beetles in your reference books to make sure you can distinguish those that do harm from those which are helpful, like the *lady-bird beetles.*

Juice Suckers.—A mosquito does not "bite." It punches a little hole in your skin and sucks blood through a tube-like mouth. Many other insects feed upon plants much in the same way. These *juice suckers* have mouths adapted for sticking into the leaves and tender stems of plants and sucking the juices. They often kill plants by taking so much juice.

Wide World Photo

The Work of Caterpillars.—Millions of tent caterpillars swept through this forest area in Michigan. The caterpillars completely stripped the trees of their leaves.

Plant lice or *aphids* are a familiar example of sucking insects. The common *squash bug* and the apple *red bug* are other examples. They are true bugs. Their life history is similar to that of a *butterfly* and *moth*.

There are many kinds of plant lice. Their eggs, laid in the fall, last over winter. In the early spring they hatch out into lice. They mature in a week or ten days. Many of the lice from the winter eggs are females which lay more eggs. There are as many as three or four generations in a season. The eggs laid in the fall carry the race over the winter months.

Juice suckers must be controlled by "contact" poisons, which must touch the insect to kill it. Nicotine, pyrethrum, and DDT are common garden contact poisons.

Mexican Bean Beetles.—This insect is a kind of ladybug, but is harmful instead of helpful. These beetles and their young eat the leaves of such beans as bush and pole beans, lima beans, and kidney beans. When they cannot get beans, the beetles eat cowpeas, soybeans, sweet clover, and alfalfa.

GENERAL PROBLEM 3

How Does Nature Help Control Harmful Insects?

Helpful Insects.—It is fortunate for the farmer and gardener that nature helps control the harmful insects. Other insects, toads, snakes, and birds all destroy many thousands of insects each year. The life history of useful insects is similar to that of the enemy insects. Only their habits or customs differ. Many of the enemy insects are *vegetarians*, as, for example, the potato beetle. Insects that help you in your war upon harmful insects are *carnivorous*. They prey upon other insects at one stage or another of their life history. Usually they make their attack on the vegetarians. The *ladybird beetle*, our familiar friend, the ladybug, eats countless numbers of plant lice. There are more than 2000 species of these beetles.

All but a few of them feed on small insects or on the eggs of insects. They are usually of a bright color with dark spots on the wing covers, or dark-colored with bright spots. They have biting mouth parts.

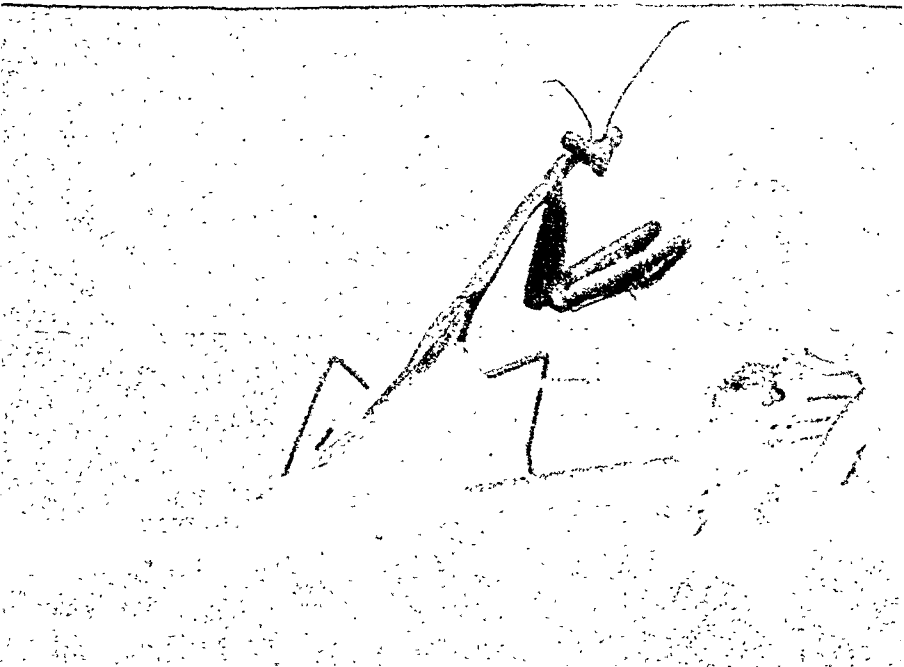
The *praying mantis* is another helpful insect. His long-jointed front legs have claws on the end with which he captures unwary insects.

FIELD RESEARCH

Fix the appearance of a praying mantis in your mind by studying the picture. Then try to find one in your yard. It is colored green or brown for protection, so you will need to look carefully. You are most likely to find it in the early fall. If you find one, capture it and place it with grass and twigs in a glass with a cloth cover. Catch a fly and put it alive with the mantis. Watch the actions of the mantis to find out how it moves, catches its prey, and how it eats.

A Garden Friend.—This close-up gives us a good view of the praying position of the praying mantis. The mantis has a tremendous appetite and is a friend to farmers because it eats many harmful insects. In fact, the European mantis is being purposely brought to this country to prey on enemy insects.

U. S. Department of Agriculture



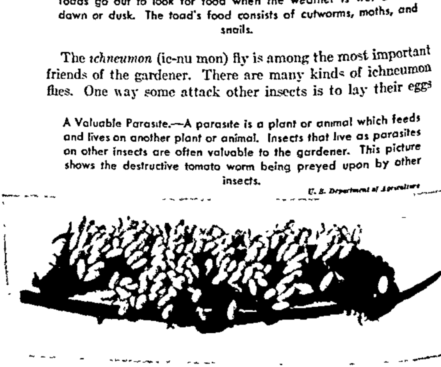
Courtesy Henry B. Kane

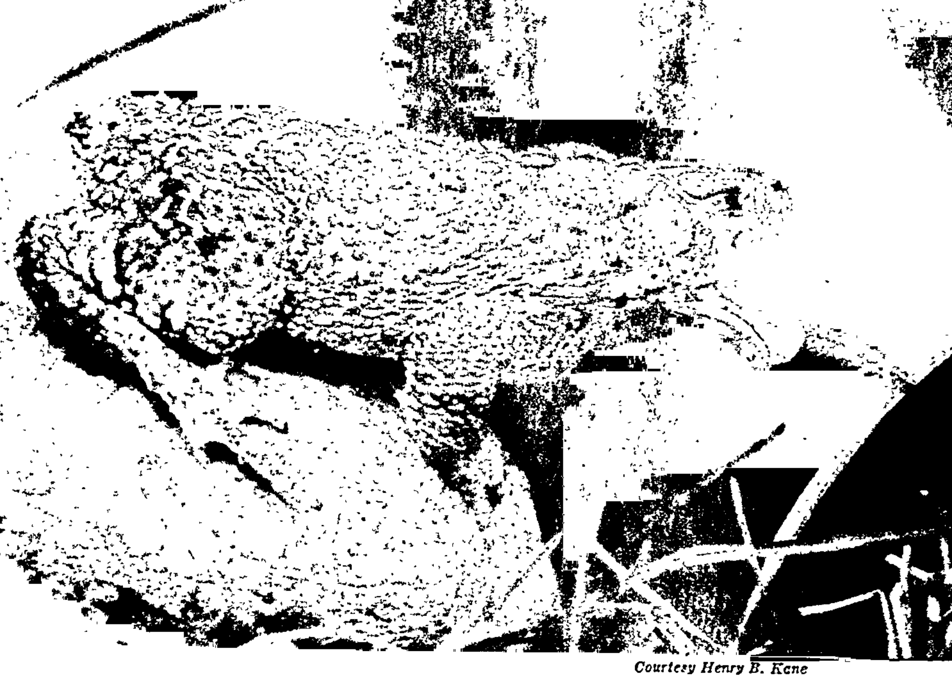
A Deadly Marksman.—The toad is a fine garden friend. He saves the farmer many dollars a year because of the cutworms he eats. Toads live in fields and gardens, under porches and by roadsides. Toads go out to look for food when the weather is wet and at dawn or dusk. The toad's food consists of cutworms, moths, and snails.

The *ichneumon* (ic-nu mon) fly is among the most important friends of the gardener. There are many kinds of ichneumon flies. One way some attack other insects is to lay their eggs

A Valuable Parasite.—A parasite is a plant or animal which feeds and lives on another plant or animal. Insects that live as parasites on other insects are often valuable to the gardener. This picture shows the destructive tomato worm being preyed upon by other insects.

U. S. Department of Agriculture





Courtesy Henry B. Kane

Unlucky Caterpillar.—An insect the toad wants to eat has little chance against his swift tongue. Its movement is so quick that it can be recorded only with a high-speed camera. The toad's tongue is attached at the front of his mouth, so that it can be easily thrust out. The tongue is also very sticky, thus making it more difficult for an insect to escape.

beneath the skin of their victims. When the eggs hatch, each larva bores its way into the body of the insect. Of course the victim soon dies.

Some ichneumon flies lay their eggs on the skin of the insects they attack. Others lay their eggs near the victim so that the larvae after hatching may find their way to their prey. Plants and animals that live upon the living tissue of other living animals are called *parasites*. Of course parasites always weaken or kill the animal that they live on.

Protection for Helpful Insects.—If we are able to recognize our friends among the insects, we can leave them unmolested. They are able, for the most part, to take care of themselves. Places, however, are provided for the scientific breeding of certain much-needed insects, such as the ladybird

Courtesy Henry B. Kane

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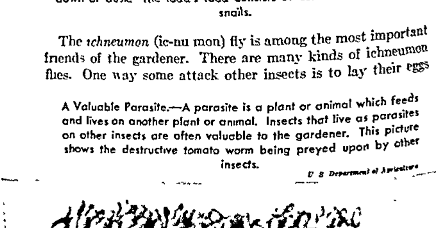

Courtesy Henry B. Kane

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Protection for Helpful Insects.—If we are able to recognize our friends among the insects, we can leave them unmolested. They are able, for the most part, to take care of themselves. Places, however, are provided for the scientific breeding of certain much-needed insects, such as the ladybird beetle. They can then be distributed to localities needing help in controlling harmful insects.

TOADS.—Science has shown us the way to secure facts and to use the facts to draw conclusions. Do you believe that toads cause warts? The toad has a warty-looking skin, but no one ever "caught" warts by handling toads. If you can find a toad in your garden, capture him and examine him closely. He will neither bite you nor give you warts. In fact he will rather enjoy the warmth of your hand.

The toad has a lightning-quick tongue with which he catches flies and other insects. He is especially fond of large larvae or grubs that try to destroy the roots and leaves of your garden plants. He eats ants, spiders, potato bugs, aphids, beetles, and worms. In a year a toad in your garden may eat 10,000 garden enemies. Toads sleep during the day and do most of their hunting at night. Study the pictures on pages 452 and 453.

Toads and frogs are cousins and have much the same manners and customs. The adult frog, however, prefers to live in and near the water, while the toad is more adventurous. He travels long distances from the pond where he was once a little tadpole, living in the water. While a tadpole, he breathed by means of gills much as a fish breathes. As a grown-up toad he gulps in air and forces it into his lungs to get the oxygen. The adult toad is a land animal.

Very early in the spring the toads travel to a pond to lay and fertilize their eggs. The female toad lays from 4000 to 15,000 eggs in the water. The male toad deposits *sperm* (fertilizing) cells over them. These find their way into the eggs, one sperm cell for each egg. Once inside the egg, the *nucleus* of the sperm cell unites with the nucleus of the egg. The union of the two nuclei is called *fertilization*, and unless this takes place the eggs will not develop. By the end of about 12 days the eggs have developed into tadpoles. The tadpoles grow and gradually develop legs. Their tails disappear and they crawl out on land as toads. They have changed from water animals to land animals.

The adult toad passes the winter in a hole in the ground or lake mud where it hibernates.

Since toads help to protect your garden by eating large

Lynwood M. Chace

A Garter Snake.—This snake, harmless to us, is about to gulp a tiny beetle. A wise gardener is pleased if he finds that there are a few garter snakes in his garden. It is fascinating to watch snakes feed, for they swallow their food whole.

numbers of insects, you should protect the toads. Leave their resting places undisturbed, and do not destroy their breeding places. Tell others what you have learned about toads, and enlist coöperation in protecting them.

FIELD RESEARCH

Collect some toads' eggs in the early summer, and put them into an aquarium where you can watch them change out into tadpoles.

Snakes.—Why is it that so many people are either afraid of snakes or at least dislike them so much? It is true that there are a few harmful snakes, but by far the most snakes are real helpers.

The rattlesnake is the most-talked-of poisonous snake. Even so, only a small proportion of people bitten by rattlers die if the bite is properly cared for. Rattlers usually do not attack people unless they are surprised or cornered. Of the many kinds of rattlers the diamond-backed is about the worst.

These grow to an average length of about seven feet. Rattlers feed by day except when it is very hot. They eat great numbers of rats and mice. In this way they are a real help to farmers.

Have you ever wondered about a rattlesnake's rattles? Like some insects, snakes shed their skin when it becomes too small on account of their growth. The first skin the rattler sheds leaves a sort of knob on the end of its tail. As more skins are shed, little rings or segments are left and held on by the knob. When the tail wiggles, these rings make a noise that warns one a rattler is near. The age of a rattler cannot be told by the number of rings because a snake may shed its skin several times a year.

Some common non-poisonous snakes are the garter snake, king snake, ribbon snake, gopher snake, and green snake If you have any of these where you live, you will be interested in studying them at first hand. You need not be afraid of them.

Perhaps the most common snake in the United States is the garter snake. That is a good thing because the garter snake is very useful It eats grasshoppers and many other insects. It also eats tadpoles and small fish if it can get them. Larger snakes, hawks, and bitterns are the worst enemies of the garter snake.

If you can catch a garter snake, put it in a glass box with gravel in the bottom and a dish of water. Find it a few earthworms every 5 or 6 days and you will soon have an interesting pet. You can handle it without any danger. Sometimes it may give off a disagreeable odor if frightened, but this does no harm.

The garter snake mates in early spring and in the fall gives birth usually to 20 to 40 young snakes. Sometimes there may be 50 to 75 young.

You can recognize the garter snake by the colored stripes that run along its back. These are green and yellow or orange, and make a beautiful pattern against the darker green of the body.

Another very common little snake is the green snake. He is very hard to see against the leafy plants where he rests This little snake eats many spiders, grasshoppers, crickets, and smooth caterpillars. He does not appear to like the woolly ones. As as insect eater the green snake is most helpful

L. W. Brownell

Busy Burrower.—This earthworm is at the entrance to his burrow. Much worthwhile work in gardens and farms is done by earthworms. They dig many burrows, thus filling the soil with air holes. This makes the soil more capable of holding air and moisture. Further, the castings of earthworms make the soil very fertile.

As a science student you should not let superstition or misbelief determine your thinking toward snakes. Learn the facts about them and then you will enjoy seeing them and want to protect them.

Birds.—No doubt you like birds better than snakes. That is to be expected, because most people like birds and say nice things about them. Then, too, they are probably more helpful to us. Let us see how the birds help us in our war on the insects.

Two common birds, the *phoebe* and the *kingbird,* make a specialty of darting after flying insects. Phoebe will tell you its name if you listen. The kingbird shows a white band across the end of his tail as he darts from the top of a tree to capture his prey in the air. Unfortunately, these birds do not always attack only harmful insects. They may eat some useful insects. However, on the whole they are helpful friends of the gardener.

Birds that catch insects as they fly about are called *flycatchers*. Other flycatchers besides the phoebe and kingbird are the *pewee* and *crested flycatcher*. The flycatchers sit quietly as if asleep Suddenly they dart out into the air, to catch an unsuspecting insect, and then return to their perch.

FIELD RESEARCH

Some day when insects are flying about, sit quietly in a convenient spot and watch for flycatchers. (Take your Field Research Notebook with you to record your observations at the moment) Field glasses will help you to observe markings on the birds.

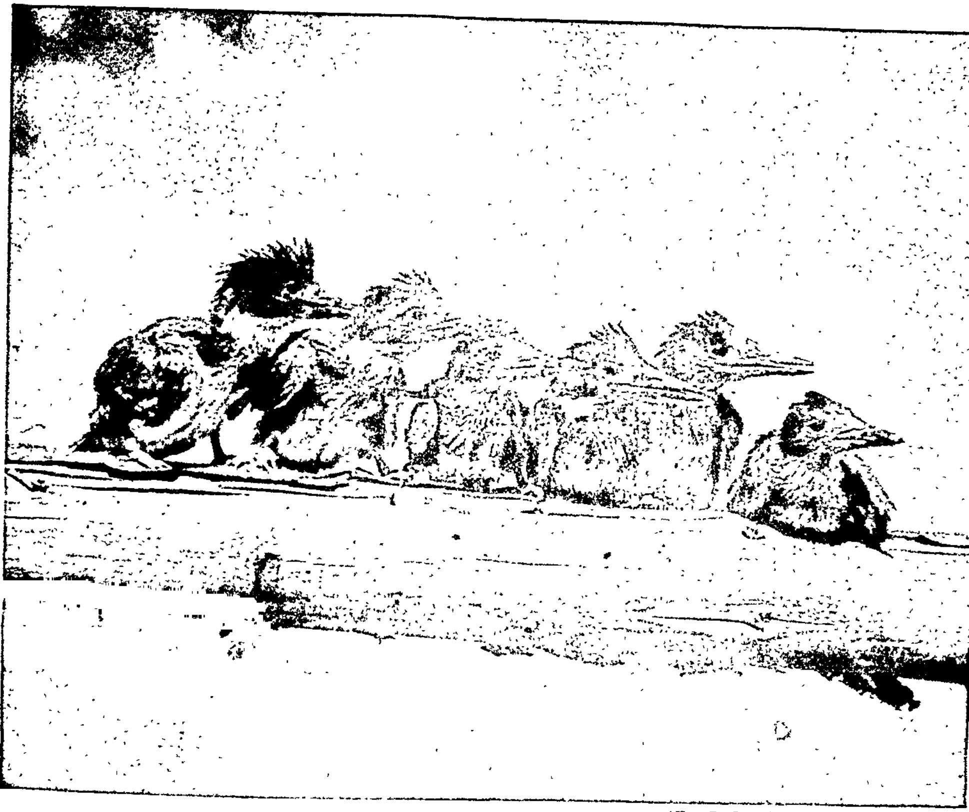
Note the ways of flying of the different birds, where they perch, their size and special markings, and the shape and size of their beaks. Listen for their calls

Record your observations and later try to identify each bird you see by reference to your notebook.

GRUB AND WORM EATERS.—Do you call anything that crawls a worm? Of course not! Snakes are not worms although there are some worms as large as small snakes. You have learned that the larvae of some insects are called *grubs*. They are worm-like but are not true worms. The grubs will change to the adult stage, if they live. True worms, of which the earthworm is a good example, reproduce new worms. But they do not go through the changes which mark the life history of insects

Many birds are fond of both true worms and the worm-like grubs Such birds are especially helpful to the gardener and farmer in eating tons of insect grubs. This is helpful because it is in the larva stage that most insects do the most harm. *Bluebirds, robins,* and *orioles* have great appetites for grubs and worms. The happy little chickadee, too, eats many larvae. In fact, in a day, one chickadee may eat several hundred grubs and hundreds of insect eggs Watch the birds to find what they eat.

EATERS OF TINY INSECTS.—Have you seen the quiet, prim little *brown creeper* hopping along the trunk or branches of a tree hunting for insects? Frequently he starts at the base of a tree and hunts along up the trunk and limbs, then darts to the base of another tree. Another little bird, the *white-breasted nuthatch*, often works head downward as he travels from branch to trunk. Both of these birds eat enormous numbers of tiny insects and eggs that are overlooked by less observing birds.



Allan D. Cruickshank

On the Alert.—These keen young kingfishers are probably watching their mother flying home with food for them. Of course, not all birds are seed and insect eaters. When these young kingfishers grow up, they will feed by catching small fish. Does the shape of their beaks suggest their manner of feeding?

Except for the *hummingbirds*, the *kinglets* are among the smallest of our birds. They like the insects that are found on evergreen trees such as the hemlock and spruce.

The *warblers* are not really good singers although they do sing very high notes. So high are their notes that some people's ears cannot hear them. There are many kinds of warblers, all small, beautiful birds. They keep very busy eating little insects and eggs. (See picture on page 468.)

The *woodpeckers* are all helpers too, especially the *hairy woodpecker* and the smaller *downy woodpecker*. These birds stay in many northern localities all winter and work day after day protecting our fruit and shade trees.

SEED EATERS.—Have you planted your garden seeds or sown some grass seed only to have the birds come along and help themselves to a free banquet? Or have they eaten the ripened seed before harvesting? It is true that birds cannot tell the difference between your garden seeds and weed seeds. However, without the feathered seed eaters it would be very difficult to keep weeds under control.

FIELD RESEARCH

With your field glass, your Field Research Notebook, an alert ear, and quick eye, go out to discover the seed eaters. Note their size, markings, where they hide when frightened, and the shape and size of their beaks. Is there any connection between these characteristics and what the birds eat?

The goldfinch is one of the few birds that sing as they fly. Listen for his song

Birds eat hundreds of tons of weed seeds. The *chipping sparrow, song sparrow, white-throated sparrow*, and the sprightly little *goldfinch* are members in high standing in the Weed Seed Eaters Bird Club. Do you know "chippy" by his cheery song? Or the white-throated sparrow by his high-pitched call saying "Poor Sam Pea-body, pea-body, pea-body"? And do you know the goldfinch which sings as he flies through the air? Wild lettuce, mullein, dandelion, ragweed, and thistle seeds are among his favorite food. How many other seed eaters do you know?

FIELD RESEARCH

Before and during nesting time the birds sing their best. It will pay you to sit quietly near a wooded lake or stream or retreat in your park at sundown and listen to them. At sunrise, too, the bird concerts are in full swing.

Learn the songs and calls of your most common birds and then try to hear the hermit thrush, the wood thrush, the catbird, or the mockingbird.

The saucy little house wren is a delight to hear. What are the best singers where you live? Listen to them until you know their songs and calls.

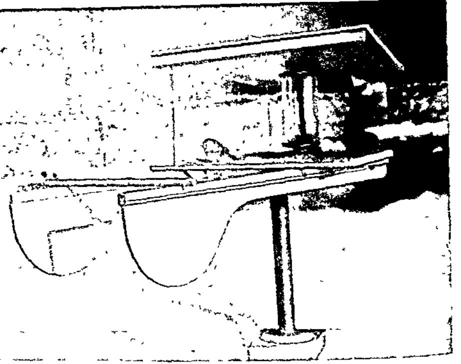
House Sparrow.—Probably all birds do some good, but a few have bad reputations. Some, like the *English sparrow* and the *starling*, drive away other more useful birds. Practically everyone in the United States knows the English sparrow, also called the *house sparrow*, because it stays around our houses. You have read how it was brought from Europe to help control some insects. But over here it didn't eat the insects as it did at home. It multiplied so rapidly that it became a nuisance. Even so the English sparrow does help in some parts of the country. Do not mistake the English sparrow for a relative of the valuable American sparrows.

Four Bad Birds.—The *cooper's hawk*, the *sharp-shinned hawk*, the *duck hawk*, and the *goshawk* are four bad birds. They rob other birds' nests of eggs or young and attack many smaller birds. The goshawk is seldom found south of the Canadian border during spring and summer. The duck hawk (page 468) is common only near large bodies of water. Only two—the cooper's hawk and the sharp-shinned hawk—need worry us very much.

Helpful Hawks.—Other hawks are most helpful because they eat large numbers of mice and similar animals called rodents. Thus they prevent millions of dollars' damage to crops and fruit trees. Hunters on the farms often try to kill all hawks—referring to all of them as hen hawks. That should not be done. Most hawks are among the farmer's best bird friends. The beneficial hawks include the *Harris hawk*, the *red-tailed hawk*, the *marsh hawk*, the *sparrow hawk*, and the *red-shouldered hawk*.

The red-tailed hawk is sometimes called a chicken hawk because it may take a chicken once in a while. Its food consists mostly of mice, rats, squirrels, gophers, rabbits, shrews, grasshoppers, beetles, snakes, and frogs. Anyone who has had a fruit orchard badly damaged by mice and rabbits will welcome the red-tailed hawk.

The red-shouldered hawk is a real friend because it eats many mice and insects. The best hawk of all is the marsh hawk. Fortunately it is found in almost all parts of the United States and Canada. If you want still more facts about the hawks, it will pay you to read about them in some book on birds.



A Bird Lunch Counter.—Two cold and hungry chickadees are finding relief from the troubles of winter in this feeding station. If you study this feeding station carefully, you will probably be able to build one. You can use wooden sides instead of glass. What is the purpose of the two large vanes?

Bird Baths and Lunch Counters.—Do you like to have the birds near you? Of course you do; not only for their songs, but because you know their value. In the summer, birds must have water for drinking and bathing. If you provide bird baths, many birds will visit your yard and help in its upkeep. A bird bath should not be very deep. It should have sloping sides so that a bird may wade into deeper water gradually. It should be placed on a standard so the house cat cannot sneak up and capture an unsuspecting bird.

In parts of the country where winters are severe, birds that stay may have difficulty in securing enough food. To help these winter birds, you should build lunch counters and keep them supplied with food. Suet fastened to a tree will coax the woodpeckers, tree sparrows, juncos, and nuthatches. Sun-flower seeds, hemp seeds, squash and pumpkin seeds, corn, oats, and nutmeats are also appetizing to birds. Seeds may be put into a little box from which the birds may get them. Or you may throw them on the ground kept free from snow.

For more details and directions for making bird lunch counters you will need to consult your Observers' Club Calendar and other books on birds. The Emergency Conservation Committee and the National Audubon Society will also give you information. It is important to remember to get your food out early so the birds will know where to find it.

FIELD RESEARCH

With the help of your science teacher, your bird club chairman, and your shop instructor, start a contest for building bird homes, bird baths, and winter lunch counters. Make an exhibit of everything constructed. In your Observer's Club Calendar you will find helpful suggestions.

Bird Protection.—Cats are valuable, particularly on farms. because of the rats and mice they catch. But in cities, cats often become one of the chief enemies of birds. If you have a house cat, keep him well fed and he will not be so likely to want to hunt for birds. Keep him shut in during the early morning and evening, when birds are most apt to be about. Tie a bell about his neck to warn the birds if he tries to waylay them.

Stray cats should not be allowed to roam. Have all stray and homeless cats taken away by the Humane Society or other authorities. Birds are valuable to your garden. You will want to do your share to protect them.

FIELD RESEARCH

Get a copy of the bird and game laws and learn what birds are protected by law. Report violators to the proper authority in your locality.

National problems of bird protection are the work of the Fish and Wildlife Service of the Department of the Interior. Among others, two laws are of special importance in protecting our birds and other wild life.

Curiously enough, one of these acts, the Lacey Act, came about because of the English sparrow. You remember that this sparrow was brought to our country to help rid the country of certain insect pests. However, the English sparrow is very hardy and soon became adapted to our country. It increased in numbers so rapidly that in some places it crowded out our native songbirds. The Lacey Act now makes it illegal to bring to this country any undesirable bird or animal. The act also serves to stop the hunting of protected birds and animals for market or for their feathers.

The second important act is the Migratory Bird Treaty Act. A similar act for Canada is called the Migratory Birds Conservation Act. These acts help to protect all birds that migrate between Canada and the United States.

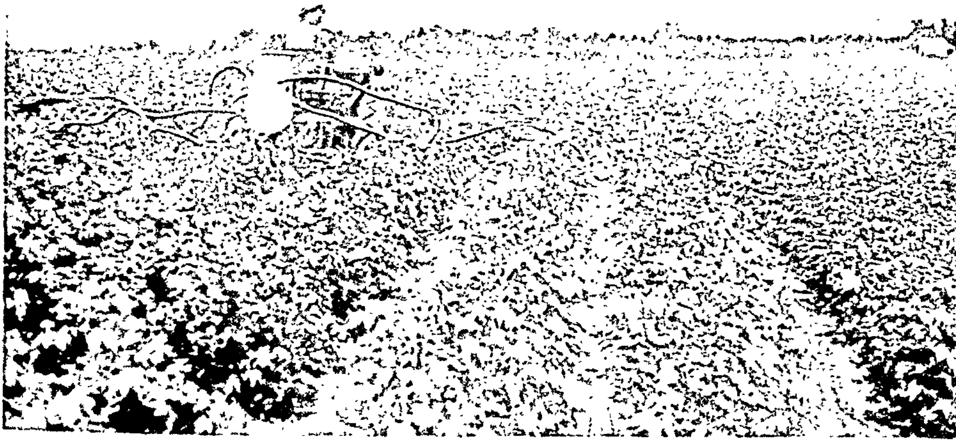
There are national and local organizations for the protection of wild life. Wouldn't you like to learn about them, about their work, and how you can help?

GENERAL PROBLEM 4

How Can Plant Diseases Be Controlled?

Sickness among Plants.—Like people, plants may have contagious diseases that are caused by germs. Therefore, it is important to recognize some of the most common diseases and know how to treat them.

With plants as with ourselves, it is important to know the signs of sickness It is equally important to know what to do to prevent other plants from catching the same disease if it is contagious. Certain kinds of bacteria cause a *blight* of the leaves and young stems of fruit trees such as quince, pear, and apple. Blight may often be recognized by leaves turning yellow when they should stay green. Germs or spores which cause the blight may enter a plant through the pores. Or they may enter through a branch which has been broken or cut. That is why tree surgeons always paint the fresh cut end of a limb of a tree The disease germs may infect other trees by contact or they may be carried by insects. Dutch Elm disease, for example, is spread by an insect which carries germs from tree to tree.

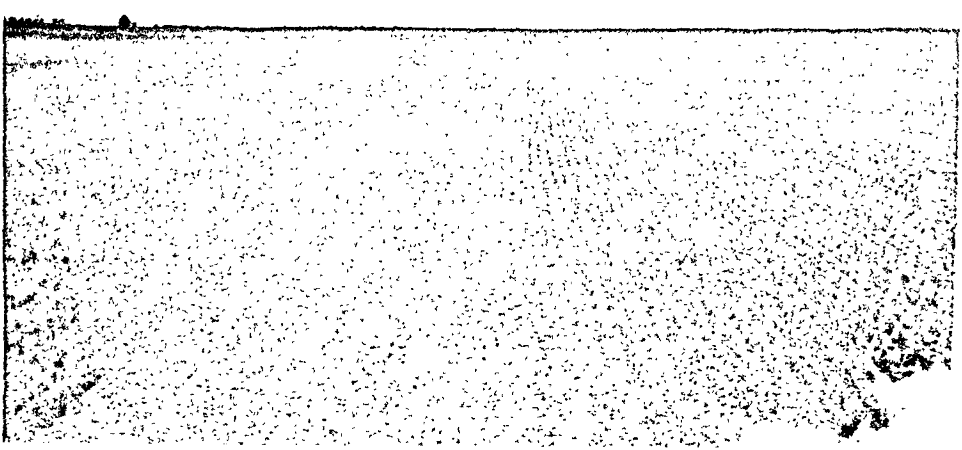


F. Miller

Insect and Disease Control.—With this equipment one man is able to dust five rows of cotton at the same time.

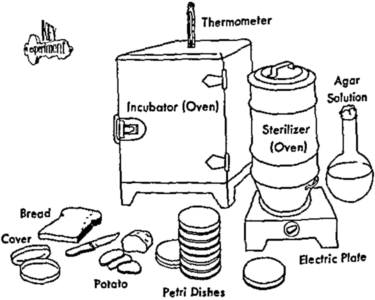
Serious Damage.—The center section of this field of young wheat was not sprayed. The plants have become diseased and are dying.

Bob Taylor



(KEY) EXPERIMENT 39

Will germs and molds grow best when cold (40°–50° F.), warm (90°–96° F.), or hot (212° F.)?



The oven and sterilizer shown in the drawing are like those usually found in science laboratories However, if you do not have them, you can do the experiment pretty well without them The sterilizer is really a steam oven. Instead of it you can use a regular oven that can be kept at a temperature of about 220°, which is necessary to kill all the germs in the agar solution to start with. This same kitchen oven can be regulated to about 212° F. for the experiment A covered pan placed on a hot radiator will serve for the 98°–100° F temperature.

WHAT TO USE.—Samples of stale moist bread; clean raw potatoes, 9 petri dishes and covers; agar solution, a refrigerator; an incubator (oven that can be kept at a temperature of 90°–100° F); and a sterilizer oven that can be kept at a temperature of 212° F.

WHAT TO DO.—1. Place a sample of the moist bread in each of three petri dishes Expose each one to dust and cover with a beaker. Label them "cold," "warm," and "hot," and place in ovens or refrigerator accordingly

2. Cut three thin slices from the center of the potato and place one piece in each of three petri dishes. Cover each and place the covered

dishes in the sterilizer and sterilize them for 20 minutes (heat them at 220° F. for 20 minutes).

Moisten your fingers and lightly rub a spot on each piece of potato, using a different finger for each slice.

Label the dishes respectively "cold," "warm," and "hot," and place along with the bread samples.

3. Place melted, sterile, nutrient agar in each of three sterile petri dishes with covers. Allow to cool and expose to the air in a dusty room, or allow a fly to track across the agar in each dish.

Label "cold," "warm," and "hot," and place the dishes with the others.

WHAT HAPPENS.—After 24 hours examine each material (by looking through the glass cover which should not be removed). Record your observations and continue the experiment another 24 hours.

Examine and compare your observations with those of the previous day.

The experiment with the bread may have to be carried on for several days.

CONCLUSION.—Under what temperature conditions do molds and bacteria grow best?

APPLICATION.—What may cause moist clothes to mold if they are rolled up and put away where it is warm?

Cabbage black rot is a bacterial disease which destroys cabbages and turnips.

Another class of plants, called *fungi*, cause even more plant disease than bacteria. One fungus with which you are familiar is the ordinary *bread mold.* Molds grow on the surface of fruits and on the leaves of many plants. Other examples of fungi are toadstools, puff-balls, and mushrooms. Experiment 39 shows the conditions under which molds develop.

FIELD RESEARCH

Place a piece of damp bread on a plate and cover it with a glass. Observe the formation of mold for three or four days. Examine some of the mold with a microscope.

Mold fungi occur in different colors. However, they do not contain any of the green coloring matter, called *chlorophyll*, of ordinary plants. Thus fungi cannot make starch as do the green

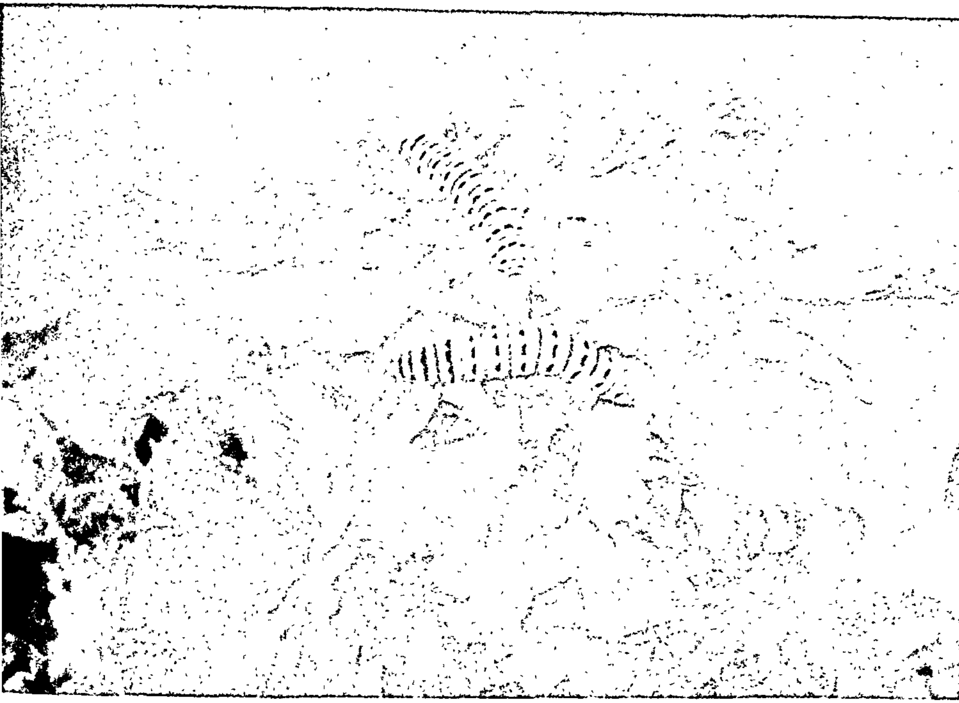
Edward A. Hill

Yellow Warbler Family.—The yellow warbler is a friend Hungry mouths in her nest keep mother bird searching for insects.

Friend and Foe.—The flicker (left) lives on harmful insects from the bark of trees. The duck hawk (right) preys on friendly birds.

Edward A. Hill

Edward A. Hill

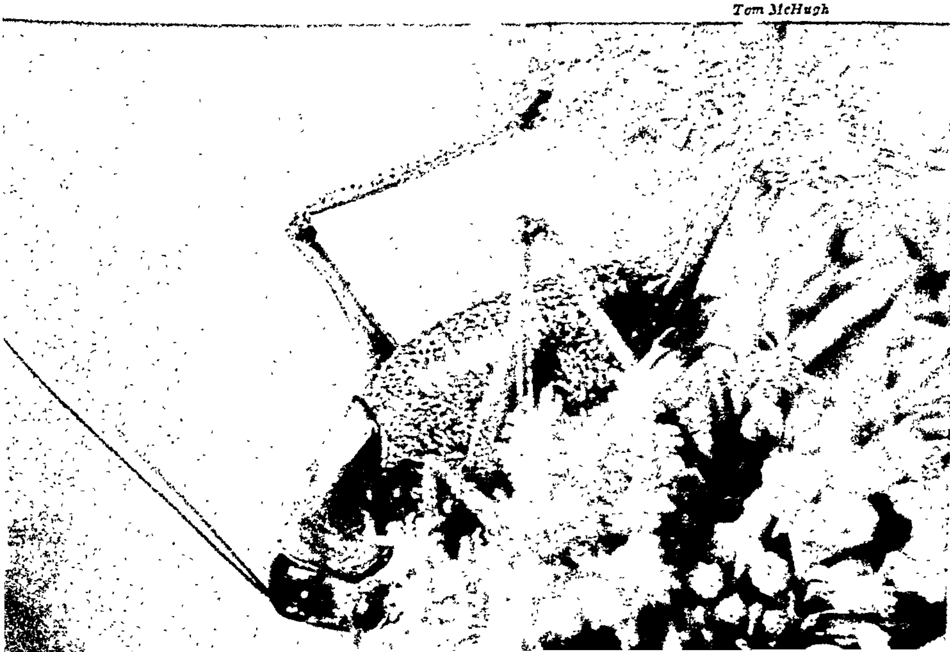


Bob Taylor

Biting Insects.—The caterpillars are rapidly stripping this plant of its green leaves. With the leaves gone, the plant will soon die.

A Mormon Cricket.—These pests are also biting insects. Both Mormon crickets and caterpillars may be controlled with proper sprays or dusts.

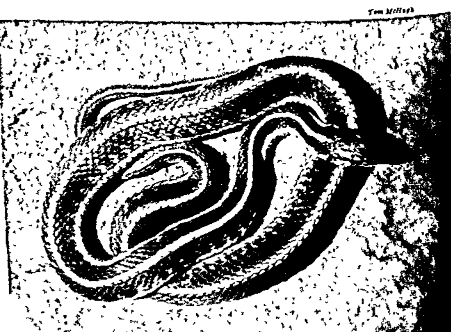
Tom McHugh

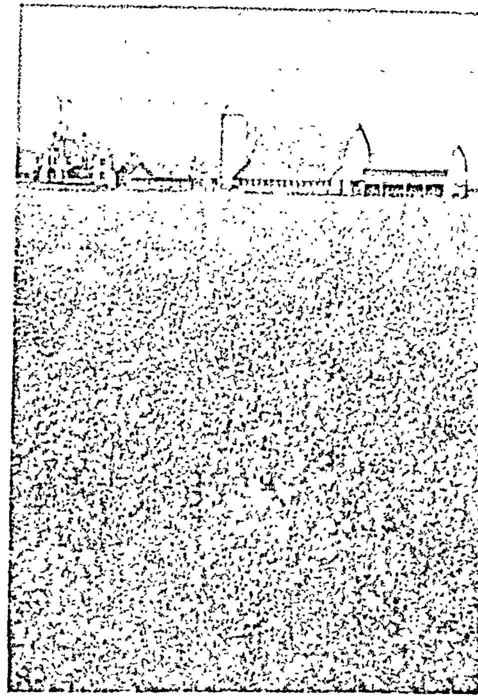


H Zenkt

Which Is a Friend?—The soft, furry snowshoe rabbit does not look like an enemy. However, rabbits destroy many young trees by gnawing their tender bark. On the other hand, the garter snake is a real friend How is he helpful to the farmer and gardener?

Tom McHugh



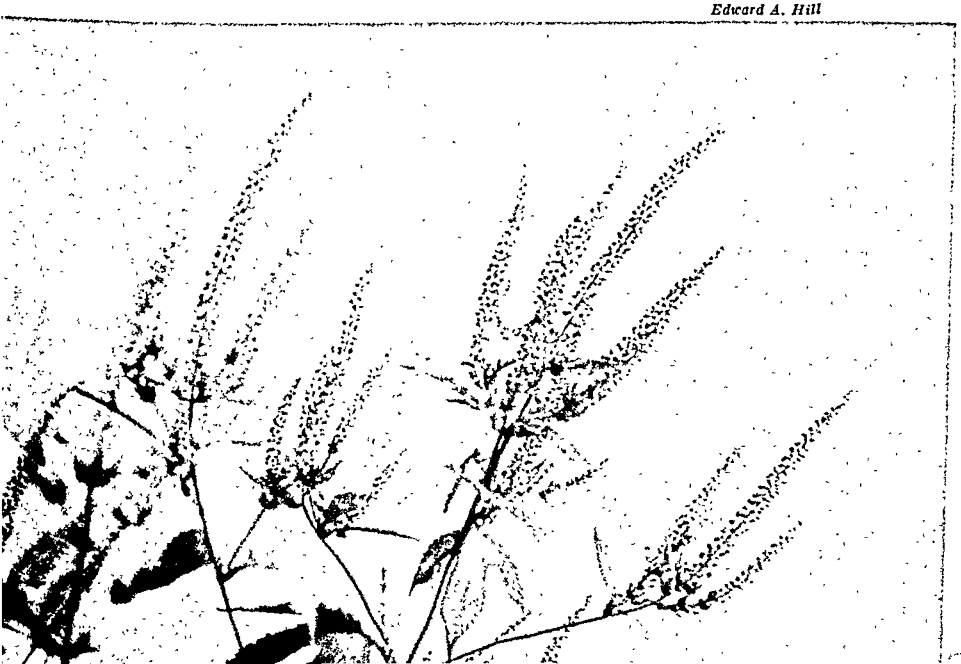


Edward A. Hill *R. A. Hotin*

Beautiful but Dangerous.—Each milkweed pod (left) produces hundreds of seeds which the breeze carries far and wide. The golden mustard plant (right) spreads so fast it chokes out crops.

Sneeze Plant.—Ragweed pollen causes hay fever in many persons. Why does the first killing frost bring relief to hay-fever sufferers?

Edward A. Hill



of the pollen unites with the ovules is called *fertilization*. In a similar way the sperm from the male frog unites with the frog's eggs to fertilize them. Unless the ovules are fertilized, they will not develop into seeds that can grow new plants. Pollination and fertilization, therefore, are two very important processes for the production of seeds. Anything that helps or hinders these processes is of vital importance to the gardener.

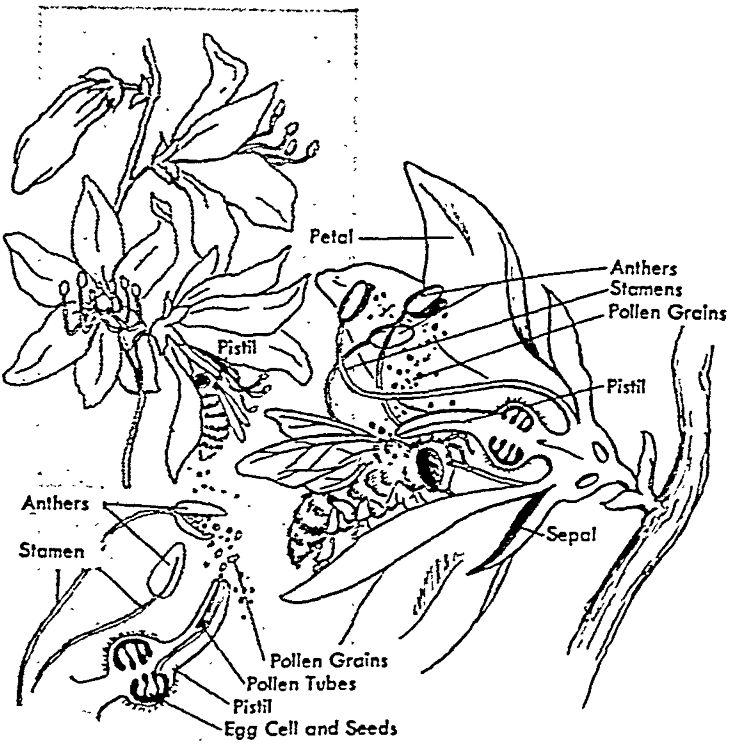
FIELD RESEARCH

If you have a microscope at home, or one at school which you are allowed to use, examine pollen from two or three different kinds of flowers. Discover whether all pollen is alike in shape, size, and color.

INSECTS HELP POLLINATION.—A few flowers are so arranged that the pollen of their stamens is likely to fall onto their own pistils. Such pollination is called *self-pollination*. However, in some flowers the stamens may be missing, or the pistil may be missing. Or the flower may be arranged in such a way that the pollen cannot fall on the pistil of the same flower. Sometimes the ovules and pollen in the same flower do not ripen at the same time. Pollen from one flower is then necessary to fertilize the ovules of the other. For these reasons the insects and birds are needed to help the process of pollination. The drawing on the next page shows a bee helping to pollinate a flower. Notice the parts of the flower the bee touches.

An insect, the bumblebee for example, may light on a flower to drink its nectar. Nectar is a sweet liquid many flowers form and store near the base of the pistils and stamens. While the bee drinks, some pollen rubs off the stamens onto his coat. Perhaps the next flower (of the same kind) which he visits needs this pollen. It may be rubbed from the bumblebee onto the pistil of the second flower. In this way the bumblebee aids in pollination. While the wind helps by blowing pollen from one flower to another, the work of insects is very necessary. Such a transfer of pollen from one flower to another is called *cross-pollination*.

In many cases cross-pollination produces improvements over self-pollination. Of course, in some plants cross-pollination is absolutely necessary if seeds are to be formed. Cherry, plum,



Pollination.—Pollination is the transfer of pollen from the stamens to the pistil. Explain how the bee helps in this process. With the help of this diagram name the parts of a cherry blossom. What is the purpose of each part?

and peach blossoms require cross-pollination by means of insects. Better crops of apples result from cross-pollination. The honeybee is the most important insect for this work. So fruit growers frequently raise honeybees in their orchards. Butterflies in the winged stage, moths, and flies are also helpful.

Thinking Things Over.—Curious, isn't it, what makes one plant a weed and another a useful plant? In fact, the dandelion has a really beautiful flower. If only it didn't spread so easily, people would like it. But even the dandelion is not always a weed. If you look in a seed catalog, you may find dandelion seeds for sale and at a rather high price, too. Why is that? The reason is that many people like dandelion leaves to eat as greens. Some gardeners raise certain kinds for that use. When is a weed not a weed? When it serves some useful purpose. So it is with most plants. Some are more useful than others. The useful kinds are protected and nourished. The less useful are eliminated from the garden to make room for the better ones Science has shown us ways to control plants that interfere with the plants we wish to raise Science, too, has discovered ways to combat sickness and disease among plants as it has among animals.

We have found that there are both useful and harmful insects although it is probable that all insects have some value. Our knowledge of the life history and habits of insects enables us to control them to some extent. Even so we need the help of toads, snakes, and birds in the war against the most harmful insects Knowing the habits of toads, snakes, and birds, as well as helpful insects, we can supply their needs and try to protect them That is why laws have been made to prevent the slaughter of birds.

Of course the more we know about the way plants grow and reproduce, the better we can care for them. This knowledge also helps scientists to develop more useful varieties of plants

Has your study of this topic helped you to realize how important scientific knowledge is to the production of food for the world? Our next topic will explain how scientific knowledge is important to the care and preservation of crops.

Key Words

anther	insects	pollination
beetles	ladybird beetle	ragweed
bread mold	mildew	reproduction
chlorophyll	mustard	root eaters
cocoon	nectar	seeds
codling moth	nucleus	sepal
cross-pollination	ovary	sperm cell
cutworm	ovules	squash bug
fertilization	parasite	stamen
flycatchers	pigweed	tadpole
fungi	pistil	warblers
grub	plant lice	warts
hibernate	poison ivy	weeds
ichneumon fly	pollen	woodpeckers

Key Statements

1. Weeds are difficult to control because they produce many hardy seeds or have hardy roots.

2. There are hordes of insect garden pests which must be controlled but others are very useful to the gardener.

3. Some insects help in the control of other injurious insects.

4. Toads should be protected because they destroy great numbers of insects.

5. Most kinds of snakes are useful as eaters of insects, mice, and rats.

6. Many birds eat grubs and worms, others eat seeds (weeds), and still others eat flies. Such birds are helpers of the gardener.

7. There are a few varieties of birds classed as pests because they seem to do more harm than good.

8. Birds can be encouraged to stay in your neighborhood if you will provide them with nesting places, nesting material, water for bathing and drinking, and food.

9. Cats are among the greatest destroyers of song birds.

10. Plants may contract contagious disease in much the same way that animals do.

11. A plant may be attacked by other plants called fungi, which eventually kill it unless the fungi are destroyed.

12. The natural purpose of a plant is to reproduce its kind.

13. Flowers contain the organs of reproduction in plants.

14. Pollination, one step in reproduction of plants, consists of the transfer of pollen from the stamens to the pistil.

15. Fertilization, the second step in plant reproduction, consists of the union of the nucleus of a pollen grain with the nucleus of an ovule (egg cell).

16. Birds and insects help transfer pollen and so aid the process of pollination.

17. When the pollen of one flower is transferred to the pistil of another flower, the process is called cross-pollination.

18. Cross-pollination of many fruit trees depends upon the honeybee.

Thought Questions

1. Account for the wide distribution of weeds.

2. How do control measures differ for weeds that are annuals, biennials, and perennials?

3. Why are weeds objectionable?

4. Where is it safe to use 2,4-D? Where should it not be used?

5 How does a ladybird beetle differ in customs and manners from a tomato worm?

6 Why are some insects called "biting" insects?

7 Why are some insects called "sucking" insects?

8 What difference in the use of insect poison is required for biting and for sucking insects?

9 How can you tell whether a plant is being attacked by an insect or a disease? What is the difference in treatment?

10 Explain how it is possible for an animal to live first as a water animal and then as a land animal. Does a land animal ever change to a water animal?

11 What does hibernation mean?

12 What peculiarities of the phoebe cause it to be called a fly-catcher?

13 What sort of beak do most seed-eating birds have? How would it compare with a flycatcher's beak?

14 What characteristics, other than shape, size, color, and markings, should help you to identify birds?

15 Why will bird baths help to keep birds in your yard?

16 How does a plant take in water and minerals through its roots?

17 Where do plants get the energy to enable them to make their food from the raw materials?

18 Why must pollination take place before fertilization?

19 How are new plant varieties produced? Consider cross-pollination

20 In what way is the honeybee a most necessary insect?

21 What are the advantages and disadvantages of spraying a whole region with DDT to kill off flies and mosquitoes?

22 Why are there more frequent epidemics of grasshoppers in the west and midwest than in the east?

Projects for Your Science Discovery Book

1 Make a collection of all the different kinds of weeds that grow about your house and tell how each one is reproduced. Suggest a plan for the control or extermination of each.

2 Draw a picture of a dandelion seed and suggest a plan for controlling it. How can you put your plan into operation?

3 Make a list of poisonous weeds

4 Examine the soil about a plant that has been cut off by a cutworm to see if you can find the cutworm larva. Put the larva into a cage with some soil and plants and observe it in its various stages Describe your discoveries

5. Make some labeled drawings of mold from your own observations.

6. Study the actions of a toad; find out what he eats and how he catches his prey, and if he has a home spot, and if so, when he stays there.

7. Try to catch a garter or green snake and keep it for a while. Be sure to feed and water it properly.

8. Observe the habits of a robin, bluebird, oriole, or mocking bird to find out what it eats, and what it feeds its young at nesting time. What is its song?

9. Describe a woodpecker, what it does, how it flies, and how its color helps protect it.

10. Make a labeled drawing of the parts of an apple blossom, trillium, or other flower.

11. Report on how many kinds of flowers in your garden are visited by insects and what insects make the visits.

12. Learn to identify garden and lawn weeds. How can they be controlled?

13. Spray all but one section of your lawn with 2,4-D. Three weeks later make a spot check and comparison of weeds on square foot basis for the sprayed and not-sprayed sections.

14. Learn to identify ragweed, goldenrod, and poison ivy. How can they be destroyed?

15. Make a study of the life history of a sucking insect, a biting insect, and a root eater. How can each be controlled?

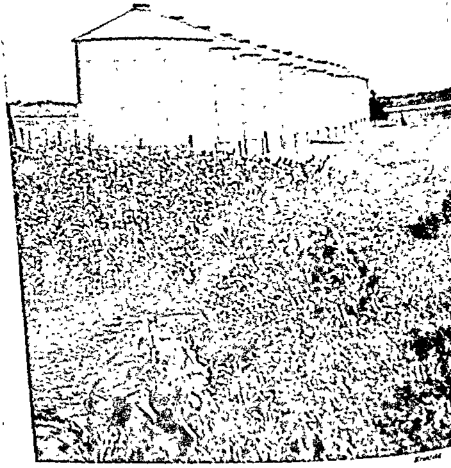
16. Find out how some aphids are cared for by certain ants and how the ants are paid for their care.

17. Learn to identify three helpful insects. How can they be protected?

18. Visit near-by farms and try to find examples of apple- or pear-tree blight, or black rot on the cabbage or turnip. Learn what the farmer does to control the diseases. If you find diseased material, go back again with your teacher, taking along several petri dishes with prepared culture medium. Dust materials of the diseased plant on to the petri dishes. Keep one dish closed for a control. Take the dishes back to school and incubate them for 24 hours at 37° C.

19. Learn how to use spraying and dusting materials for the control of insects, plant disease, and fungi.

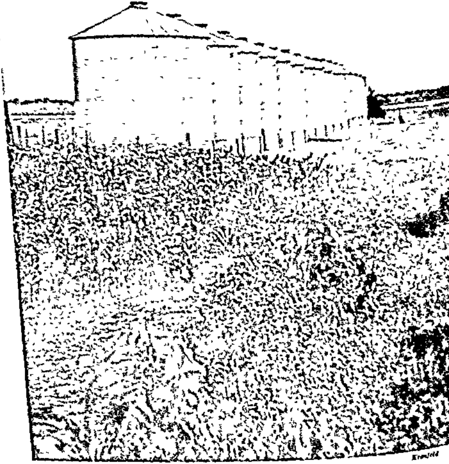
20. Go to the library for information about the Australian ladybird beetle and how it helped to control the cottony-cushion scale of California. Try to find out about other beetles and their work. The squash ladybird beetle and the bean ladybird beetle are harmful.



Grain Storage Bins.—Conservation means preventing waste. You, your county, your state, your nation, your world—all must conserve. Conservation is everyone's job.

UNIT VI

Conservation



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UNIT VI

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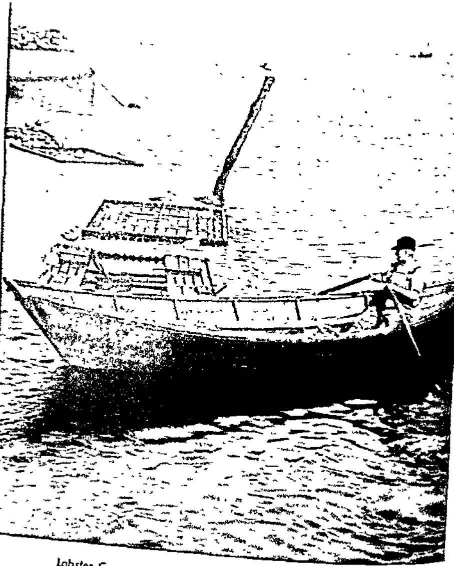


Raymond E. Hanson

Lobster Cars.—The lobster fisherman knows how to conserve, too. He catches live lobsters in traps. Then he puts the lobsters in underwater storage crates, where the lobsters are kept alive until they are needed. The storage crates are called lobster cars. You can see the tops of them in this picture.

TOPIC XVI

Food Conservation

DO YOU KNOW—

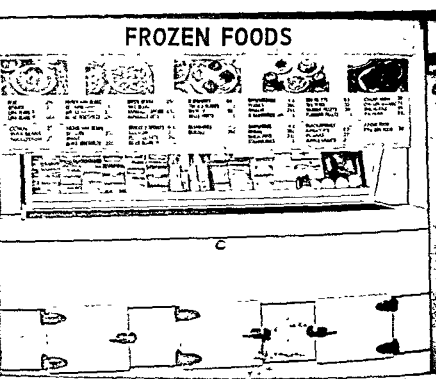
1. What causes foodstuffs to spoil?
2. How the inside of a refrigerator keeps cool?
3. How apples and potatoes should be stored?
4. Why dried apricots keep longer than fresh apricots?
5. What is meant by "quick freezing"?
6. Why pasteurized milk stays fresh longer than raw milk?

GENERAL PROBLEM 1

How Are Foods Conserved by Storing?

Air Conditions.—Foods spoil for one of several reasons. They may dry out and wilt, which makes them less useful. They may be kept so warm that molds and bacteria grow, causing changes in their composition and rotting them. The conservation of raw foods, then, depends upon maintaining proper conditions to prevent shrinking and rotting.

The proper storage of fruits and vegetables is a problem of ventilation, air temperature, and air humidity. Storage space should be clean, dry, and dark. Most fruits and vegetables should be kept between 33° F. and 40° F. to prevent the growth of molds and bacteria. Fruits which contain considerable amounts of sugar can be kept with the temperature at or near freezing.



Ewing Galloway

In a Modern Super-Market.—The signs above the counter give a good idea of the variety of foods—vegetables, fruits, fish, meats—now available in frozen form. If quick-frozen foods are to be cooked, they are put directly from the package into boiling, salted water. If the frozen food is not to be cooked before eating, it must be thawed out at room temperature for about two hours. Frozen foods should be left in the sealed package while thawing.

foods very quickly. When this method is used the food is not damaged, as when it is frozen slowly. Have you eaten peas or berries that have been frozen by the quick process? When thawed out they are like fresh-picked foods.

During the past few years frozen orange juice has largely replaced fresh orange juice. Juice from fresh oranges is concentrated (most of the water is removed), put in small cans, and frozen quickly. Thus one small can of frozen juice is equal to a dozen or more oranges.

Today many homes and farms have small freezers. Fruits, vegetables, fish, meats, and even bread, pies, and cakes may be preserved for months by this method.

FIELD RESEARCH

If there is a quick-freezing plant or unit near where you live, arrange to visit it, or send a committee to visit it for you and make a report to the class.

GENERAL PROBLEM 2

What Are Some Home Conservation Methods?

SCIENTIFIC PRINCIPLES.—You have learned that decay is usually caused by germs, by molds, and by mildews. You have learned also that these non-green plants thrive best at warm temperatures and in the presence of moisture. The preservation of food, therefore, depends upon one or more of the following methods.

(1) The food may be kept at a temperature so low that the organisms become inactive. (As a rule, they are not killed by low temperatures.)

(2) Moisture may be removed from the food.

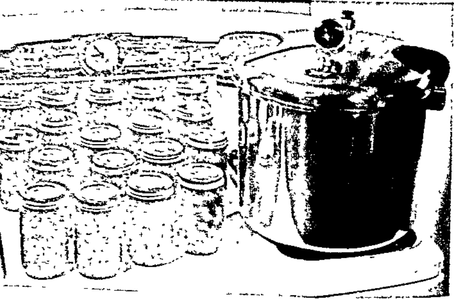
(3) The decay-producing organisms in the food may be destroyed.

(4) Substances may be added that prevent or retard the growth of decay-producing organisms.

Often a combination of these methods is used.

PRESERVING BY HEAT.—When watching your mother canning fruit or making jam, have you ever noticed how careful she was to make sure the jar was clean and hot? And did you notice how quickly she covered the hot fruit or jam after it was put into the jar? This was to prevent any dust from getting in. The dust might contain mold spores or germs that could cause the canned fruit to spoil. Sometimes the fruit may be put into the jar and the whole thing heated at the same time and then covered.

Not only fruits, but vegetables and meats may be preserved by heat. They are placed in a container and heated to a temperature high enough to kill all the germs and spores of molds. The container is then closed airtight while still hot. If you



A Pressure Cooker.—This is an extra large pressure cooker. Most pressure cookers are made of aluminum or enameled steel. Note the steam gauge and behind it the safety valve. Besides saving fuel and vitamins, pressure cookers save time. Food can be prepared in them in far less time than by ordinary cooking.

recall Experiment 39, you know that heat kills the organisms. The sealing prevents other organisms from entering.

The required temperature, which is 212° F. or higher, is obtained by placing the can in boiling water, or in a *pressure cooker*.

The pressure cooker is used for ordinary cooking as well as canning. Many modern ones are no larger than sauce pans. Their users claim that they have two advantages. They are more economical of fuel, and they prevent nutrients from boiling off in steam. The pressure cooker uses a science principle which you should understand. The temperature of boiling water and therefore of the steam formed is lower with low air pressure, and higher with high air pressure. The pressure cooker is called that because the cover fits on so tightly that when the water boils the steam cannot escape. The pressure inside, therefore, becomes greater. As the pressure builds up, the boiling water and steam get hotter and hotter. If the steam could escape, the water temperature would rise to about 212° F. and no higher. With the steam held inside, the water temperature goes up. Thus the same amount of heat will raise the temperature of the water in a pressure cooker higher than the water in an open kettle.

There are two safety precautions to remember whenever using a pressure cooker. If the steam could not escape, no matter how much the water inside was boiled, it would burst and cause damage. To safeguard against such an accident the pressure cooker has a safety valve. When the steam pressure rises to a certain point, the steam valve opens and lets some steam escape. Since the boiling temperature depends upon the pressure, this valve can be set to maintain a required temperature and no higher. This temperature is often 220° F., or eight degrees hotter than ordinary boiling water.

Whoever uses a pressure cooker must be very sure that the outlet valve is working properly. This may be determined by watching the steam gauge on the cooker which shows the pressure. If the gauge shows that the pressure is getting higher than the danger mark, the heat must be turned off at once.

A second safety precaution is: *Never remove the cover so long as the steam gauge shows any pressure inside.* As the cover is loosened, the pressure might tear it off and cause a serious accident. Also, the high temperature inside would certainly cause the contents to boil out of the cooker. Therefore, the heat should be turned off, and the pressure cooker allowed to cool to normal pressure before opening it.

The pasteurizing of milk, (pages 391–392), illustrates the effect of heat upon certain germs. This method does not use temperatures so high as those used for canning.

The pasteurizing temperature, 142° F., does not kill all the organisms in milk. It does, however, kill most of those which cause milk to sour. It also kills the germs that might cause diseases such as typhoid fever and tuberculosis. To find out for yourself what effect a pasteurizing temperature has on milk you will need to try Experiment 40. This experiment has a real practical value. If you are in the country or at camp and can buy only raw milk, you may want to pasteurize it before using it. In fact most doctors agree that it is much safer to use

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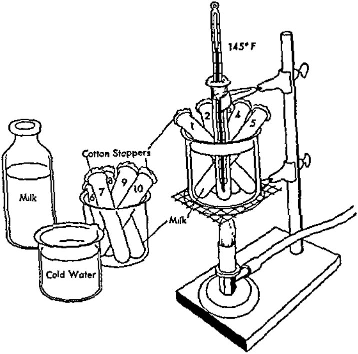
EXPERIMENT 40

Will heated (pasteurized) milk keep longer without souring than unheated milk?



The cotton "plugs" are to keep out any dust particles that may be floating in the air, because they may contain germs or mold spores

Be sure to label your ten tubes carefully, and keep in mind the different treatments the milk in each test tube receives. Tubes one to five are heated, while tubes six to ten are used for controls Why are these controls needed?

WHAT TO USE.—Ten test tubes; a thermometer; cotton; a large beaker, wire gauze, a tripod or ring stand and ring; a Bunsen burner, fresh, raw milk.

WHAT TO DO.—1. Half fill ten test tubes with milk and close the ends with tightly packed cotton stoppers Label the test tubes 1 to 10

2 Put tubes 1 to 5 in the beaker and add water until it reaches the top level of the milk in the tubes

Place the beaker on a wire gauze on the tripod or ring stand and apply heat

Put the thermometer in one of the test tubes of milk without removing the cotton stopper.

Heat the water in the beaker until the milk in the test tube is at 145° F. and maintain that temperature for 20 minutes. Is it fair to assume that the milk in all tubes is at the same temperature?

3. Remove the test tubes from the water and cool them rapidly. Set all ten tubes with the milk in them on a side bench or table in your science room.

After one day examine tubes 1 and 6, and on each succeeding day examine and record observations of tubes 2 and 7, 3 and 8, 4 and 9, and 5 and 10.

WHAT HAPPENS.—In which set of tubes did the milk keep sweet longest?

CONCLUSIONS.—State briefly how the souring of milk may be retarded.

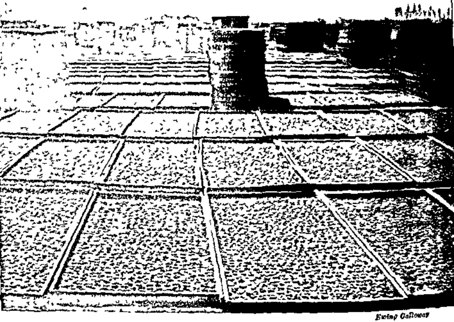
APPLICATION.—Why must pasteurized milk be cooled quickly?

pasteurized milk and cream. Also all milk used for ice cream, chocolate milk, and other milk products should be pasteurized.

Cooking, too, is based upon good science principles. Not only does cooking meat, for example, make it more tender and improve its taste, but it kills germs that otherwise might cause disease. Pork especially must be thoroughly cooked to be safe for eating. There is always a possibility that it may contain organisms that cause a serious disease which is called *trichinosis* (trĭk′ĭ-nō′sĭs). Proper cooking will kill any organisms that may be present.

PRESERVING BY DRYING.—Apples are sometimes preserved by drying thin slices. Before using, the dried fruit is placed in water for a time, during which it absorbs water and swells. It can then be used as a substitute for fresh apples.

Fruits, vegetables, and meats are usually dried artificially so that the water is removed rapidly without overheating the foods. They thus retain practically all of their essential substances. When water is added, they are very nearly like the fresh foods of the same variety. Drying is the oldest method for the preservation of food. Sometimes the drying is supplemented by smoking or salting. In this case the salt or the smoke acids act as chemical preservers.



Ewing Galloway

Drying Apricots.—Here we see acres of apricots drying in the California sun. Before being set in the sun to dry, the apricots are exposed to very high temperatures by steaming. This stops the action of destroying organisms. Next the apricots are sterilized by chemical means Then the apricots are put in the sun to dry, spread out on flat trays. The drying process takes several days.

FIELD RESEARCH

Go to your grocery store and make a list of several dried foods offered for sale Read the label on each package for special information What evidence can you find that the foods were dried according to sanitary methods?

PRESERVATION BY THE USE OF CHEMICALS —What is a chemical? That is a fair question. Any substance that will act on another and cause a change may be called a chemical. Salt and sugar are chemicals just as much as acids and alkalies. Vinegar contains acetic acid, which is a chemical. The baking soda your mother uses is a chemical. So when we talk about using chemicals to preserve foods we are using a word that includes several kinds of substances.

A strong salt solution may be used to preserve such foods as pickles, peaches, fish, and meats. This is called pickling. Jams, preserves, and jellies are preserved with large amounts of sugar. Here the foods are placed in glass jars and covered with paraffin to keep out molds and bacteria. The use of salt and sugar as preservatives, in pickling or making jellies, depends upon the process of *osmosis*. Osmosis is the mixing of two liquids by passage through a thin membrane or porous wall.

Any organism that tried to live in concentrated salt or sugar solution would have its body liquids pass out by osmosis to dissolve the salt or sugar. In other words, individual cells of the organism would dry up and die. Of course some plants and animals are adapted to the use of salt water, such as sea water. Moreover, some molds can grow on the outside of substances like salt meats and sweet jellies.

There are several other chemicals used to preserve foods. Some of these are borax, sulfites, formaldehyde, salicylic acid, and sodium salicylate. Very small amounts of these substances dissolved in the food material will prevent the growth of germs and molds. Their presence in a food must be stated on the label. Sodium silicate, commonly called *water glass*, is a chemical often used to preserve eggs. It forms an airtight and water-tight covering around the eggs, but does not touch the material inside the shells.

Preservation by Cold.—Most fresh meats, fruits, vegetables, and milk and cream are for immediate use in the home. Knowledge of the causes of decay enables us to care for such foods most efficiently. Not only do fresh foods need special attention, but opened canned goods need care to prevent waste. Even though the canned goods may have a special preservative in them, the food will spoil quickly if left in a warm place.

You have learned that the organisms that cause decay and spoiling of foods are inactive at low temperatures. Therefore, the best method of caring for foods that are to be kept for a short time only is the cold method. The foods may be kept in a cold cellar. The cellar should be dry and free from mold growths on the walls and floors. Or foods may be kept in refrigerators during warm weather, and in cold rooms during

Courtesy Ball Brothers Company

Two Ways of Storing Foods—The farmer on the left is burying his winter supply of vegetables in barrels sunken in the earth. The vegetables in each barrel will be covered with boards and they will be covered with straw or dirt. Fruits may also be buried in this way. The winter cold of the ground preserves the foods. The housewife on the right is about to freeze some strawberries and pineapples in her home freezer.

cold weather In any case, foods such as milk, cream, and butter should be kept covered to protect them from dust.

We know that fruits and vegetables and sometimes fish and meat may be kept for long periods by freezing. The special quick-freezing methods result in very rapid freezing of the material without destroying the tissue. When thawed out, the food has retained its natural freshness.

GENERAL PROBLEM 3

What Keeps the Refrigerator Cold?

HEAT TRANSFER.—The refrigerator is a small-sized cold storage plant. It is used to keep foods cold enough to prevent them from spoiling. The building of a good refrigerator depends upon knowledge and application of the principles of *heat transfer*.

To keep an object hot, it is necessary either to keep adding heat, or to prevent the loss of its heat. To keep an object cold, it is necessary to prevent heat from being added to it. Keep these statements in mind in studying a refrigerator.

You know from experience that if one end of a metal rod is heated, the other end becomes warm or hot. The heat travels, that is, is transferred from one end of the rod to the other. On the other hand, a stick of wood can be held in the hand even though the other end is on fire. In this case, heat is not transferred from one end to the other. The metal is a *conductor* of heat. The wood is a *non-conductor* of heat.

FIELD RESEARCH

Test samples of copper, aluminum, glass, stone, brick, and porcelain to find whether they are conductors or non-conductors of heat.

It has been found that heat may be transferred in any one of three different ways. Heat travels through solids by *conduction.* Gases and liquids transfer hear by *convection.* Heat may also travel through gases by means of *radiation.* Let us find out a little more about each of these methods of heat transfer.

CONDUCTION.—Ordinary matter is composed of very tiny particles called *molecules.* Most molecules are too small to be seen even with powerful microscopes. The molecules in matter are all in rapid motion, something like little rubber balls bouncing against each other.

When a substance is heated, the molecules bounce faster and harder. They strike nearby molecules and set them moving. These in turn set other molecules bouncing. Thus the heat travels through the substance. This transfer of heat from molecule to molecule is called *conduction.*

When some solids are heated hot enough they melt and form liquids (example, ice to water). The molecules in liquids bounce faster and harder than in solids. When certain liquids are heated, they change to the gas state (example, water to steam). In gases the molecules bounce still faster and harder than in liquids.

CONVECTION.—The transfer of heat from a hot object to other objects by a circulation of gases or liquids is called *convection*. The circulation results in currents called convection currents.

Convection is the principal method by which heat is transferred or distributed in liquids and gases. It is possible because the molecules are free to move from one place to another. *In convection, the heat is carried from one place to another by the molecules In conduction, the heat is handed along from one molecule to the next.*

RADIATION.—A third method by which heat is transferred is *radiation*. If you stand near a hot campfire, your face and the front of your body quickly become hot. Your back continues to stay cold. The heat seems to come straight from the fire until it strikes you and there it stops. A wire screen placed between you and the fire cuts off some of the heat. These facts are well known to you by experience.

Outdoors on a bright sunny day, the heat seems to come straight to you from the sun. Hot objects seem to give out heat. Actually they are sending out a form of energy that does not heat up gases through which the energy passes. The heat does not appear until the energy strikes a body. It then changes into heat energy, and we say the body has been warmed.

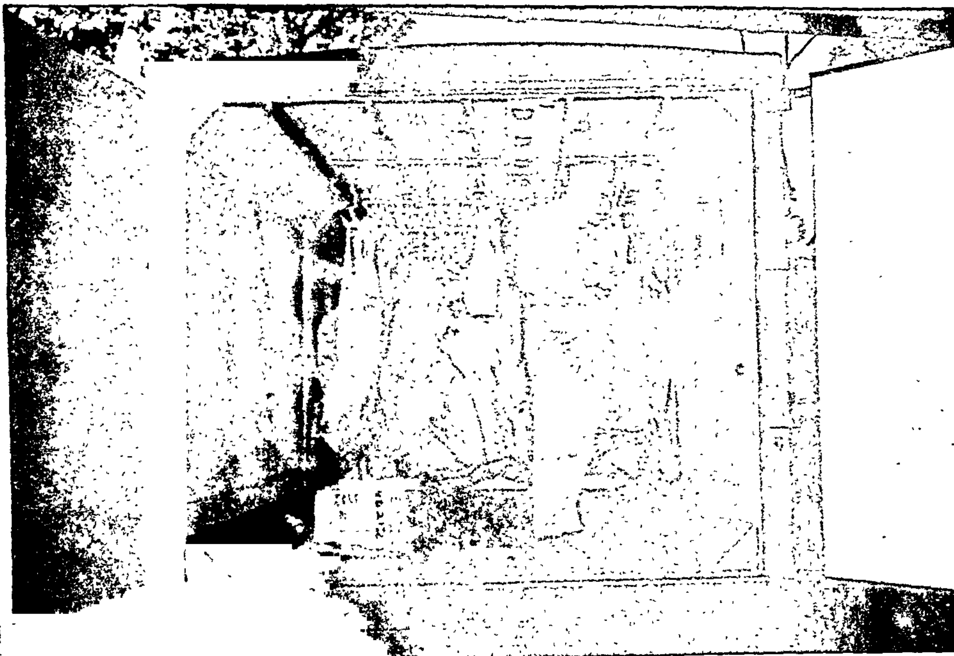
FIELD RESEARCH

Focus the rays from the sun through a hand lens or magnifier onto your hand Do the focused rays burn your hand more than the unfocused rays? Draw a diagram in your Science Discovery Book to illustrate how the sun's rays may be focused.

Try focusing rays from a red-hot object in the same way.

Try reflecting the energy from a fireplace with a mirror or piece of polished tin. Will a black or dark object reflect the energy?

The *radiant energy* of hot bodies is given off in straight lines in all directions. The hotter the body, the more energy it radiates. The radiant energy is changed to heat energy only when it is stopped and absorbed by another body. Radiant energy does not depend upon molecules to "carry" it along nor to



Signal Corps Photo

Beef for the Army.—The army officer is checking the temperature of this refrigerator truck. The truck is loaded with beef for our troops. Notice that the metal walls of the truck are kept so clean they reflect the beef in mirror-fashion. Of what advantage are metal walls in a refrigerator truck besides being an aid to cleanliness?

"pass" it along. It can, therefore, pass through a vacuum. If this were not true, it is difficult to understand how we could derive heat from the sun.

Refrigerator Construction.—The refrigerator is a device to keep things cold. The sides, top, and bottom must be built to prevent the transfer of heat into the box. Also there must be some plan to remove the heat brought in by warm foods and warm air when the door is open.

The walls of a refrigerator are hollow and filled with air and *insulating* solids. *Insulating* materials are those that help prevent transfer of heat. Air is a poorer conductor of heat than wood. But heat is transferred by convection, if the air in the space is free to circulate. Therefore, the space in the walls is broken up into small air spaces. This is done by putting in packed, non-conducting porous material. Mineral wool, cork, celotex, or small bits of certain minerals are used. Modern refrigerators have walls built of metals. This is practical because the air space in the walls can be so thoroughly insulated.

Lining the inside walls with aluminum or white porcelain helps to prevent loss of heat by radiation. How?

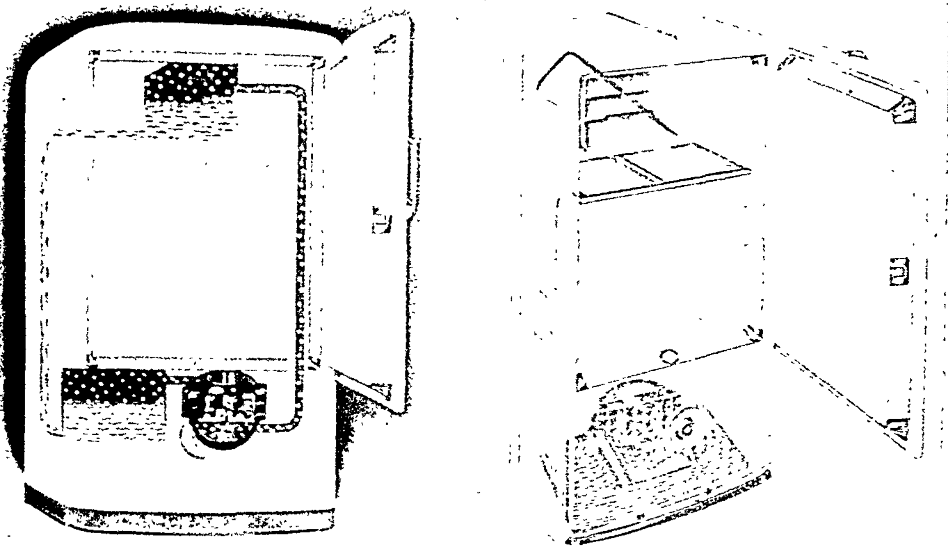
REMOVING HEAT FROM THE REFRIGERATOR.—A refrigerator is build with non-conducting walls. Therefore warm air inside will stay warm unless the heat is taken from the air and food inside. This may be done by placing ice in the box. Ice must take in heat in order to melt. The water from the melted ice flows out a drain pipe, carrying the absorbed heat with it.

When food is placed in the refrigerator, it is warmer than the air in the refrigerator. The food gives up heat to the air and becomes cold. The ice absorbs this heat from the air, keeping it cold. The ice melts and water runs out, carrying with it the heat brought in with the food. Since ice melts at the surface only, better cooling results if the ice chamber is kept nearly full of ice.

Ice Absorbs Heat and Melts

An Ice Box.—Both ice and water can exist at 32° F. Food in the ice refrigerator gives up its heat to the ice. The ice absorbs the heat and changes to water at 32° F. Thus the food is cooled. You should always close the refrigerator door promptly after taking anything out. Why?

Instead of ice for absorbing heat, modern gas and electric refrigerators make use of "freezing units." This method is better than ice since it is possible to keep the air at a more uniformly cold temperature. Moreover, these refrigerators are automatic and therefore require less attention. There are several types of freezing units, and you may want to have a committee investigate them. They all work on the same principle. When a gas expands it takes in heat, and when a gas is squeezed together it gives out heat. In the cold unit a gas is caused to expand rapidly. As a result it absorbs heat from the air in the refrigerator. This expanded and warmer gas is pumped out and



Courtesy Frigidaire

Electric Refrigerators.—At the top of the refrigerator on the left is the freezing unit. Here a special liquid evaporates into a gas, and expands. As the gas expands, it absorbs heat. The expanded gas is carried to a pump (lower right). The pump compresses the gas in a radiator (lower left), where it is changed back into a liquid. The liquid is then sent back into the freezing unit. The refrigerator on the right absorbs heat through the walls as well as in the freezing unit. Note the pipes in the walls.

compressed again. At the same time it is cooled by passing through some type of radiator. It is then ready to be pumped back into the cold unit to expand and absorb more heat.

The ice, or the cooling unit, is placed at the top of the refrigerator. Air in contact with the cold unit gives up some of its heat and becomes cooler and heavier than other air in the refrigerator. Hence it sinks to the bottom and pushes up the less cool air. As the cool air touches the food it absorbs heat from the food, leaving it cold. This warm air then moves to the cold unit, gives up its heat, and sinks. The heating of the air by the food and its cooling by the cold unit cause a continuous circulation of air in the refrigerator.

A good refrigerator maintains temperatures of about 42° F. near the bottom, and 50° F. at the top of the food chamber.

If the refrigerator is built so that good air circulation occurs, the air will deposit much of its moisture on the cold unit. Dry

Market Day.—The open-air market is still a familiar sight in many American cities. This particular one is the famous Faneuil Hall Market in Boston. Many markets feature low-priced foods. Before taking any "bargains," however, the purchaser should be sure all meat is fresh and government-stamped. He should also make sure that all vegetables are farm-fresh and healthy.

We know that milk and water are especially suited to distribute contagious diseases. Other foods such as vegetables and meats may do so, too. Therefore, all foods for human or animal use should be carefully guarded against germs. Meat markets, grocery stores, candy shops, and all other food stores should be required to observe sanitary regulations.

In most communities, foods, including milk, are required by law to be protected against flies and dirt and disease. Throughout the nation, foods must meet certain standards set by the United States Pure Food and Drug Acts. Canned foods must have labels which tell the weight of the contents and the names of any preservatives · · In the case of prepared foods, the label must tell a

Drugs and medicines must also meet the standards of the United States Pure Food and Drug Acts. All drugs are dangerous except as prescribed by a physician. Some drugs, such as narcotics, are so dangerous that druggists are not allowed to sell them without a doctor's prescription. All patent medicines must have a proper label stating the contents. The law also forbids any advertiser from making claims about his product which cannot be proved by test. No one should make a practice of using patent medicines. The best procedure is always to consult your physician.

Laws pertaining to foods and drugs are for your protection It is up to you to read the labels and know what you are buying. Alcohol and other narcotics are especially dangerous drugs They are always clearly labeled, and their sale is regulated by law. These drugs are habit-forming. Once their use is started, it is difficult if not impossible to stop. They should be taken only when prescribed by a competent physician.

FIELD RESEARCH

Ask your druggist to let you study the labels on several different patent cough medicines. Write down the contents. Are the same materials found in most of the medicines? Does the label claim that the medicine will "cure" a cough? How much of each medicine is water?

THE HEALTH DEPARTMENT.—The health of the community is particularly the problem of its Department of Health and the chief health officer. This department is responsible for proper safeguards of the milk and water supply, the sewage and garbage disposal, sanitary stores and markets, and clean streets. It must be constantly on the alert to prevent the spread of disease from any source. The Health Department needs your coöperation in upholding its standards and enforcing the laws of the country, state, and town.

THINKING THINGS OVER.—Food, along with shelter and clothing, is one of the three main necessities of life and comfort. Thus conservation of food is a major problem. Conservation means the use of a substance efficiently and without waste. Conservation of food involves the application of scientific principles to the preservation of food. If not properly cared air results You have learned that molds and bacteria grow best in warm, moist air. Therefore, low temperature and dry air remove two of the conditions under which food spoils. On the other hand we wish to prevent some foods from drying. So modern refrigerators have several compartments. One keeps the air cold and dry Another keeps the air cold but moist A third compartment is so designed that food or water placed in it may be frozen solid.

FIELD RESEARCH

Visit a store that sells a standard make of refrigerators and have the clerk explain its good points The store may have a model of the side wall that you can study to learn how it is insulated.

KEEPING THE REFRIGERATOR CLEAN.—The refrigerator should be kept very clean at all times and so its lining should be smooth, waterproof, and not easily stained. Enamel or porcelain lining is best The inside of the refrigerator may be kept clean and "sweet" by washing it frequently with a solution of washing soda The surface should then be wiped clean with clear water. Scouring powders should not be used. They cause tiny scratches which fill with dirt and are difficult to clean.

FIELD RESEARCH

Study the refrigerator in your own home to find out whether it is satisfactory; that is if constructed to permit good air circulation Does it keep a temperature below 50° F. in the warmest part? Is the lining such that it can be thoroughly cleansed? Are the foods placed in the proper location in the refrigerator? Are foods allowed to cool off before they are put in the refrigerator? How does this affect the ice or electric bill?

CARE OF FOODS IN THE HOME.—Modern refrigerators are excellent devices for conserving foods. They can do their best work, however, only when used intelligently. Milk bottles should be cleaned on the outside and placed in the refrigerator as soon as possible after delivery. At no time should milk be allowed to get warm unless you wish it to sour quickly. Nor should it be allowed to stand in the sun even on cold days because that may destroy some of the vitamins.

Meats also should be cleaned, if necessary, and placed in the refrigerator until needed for cooking. The meat should be kept covered to prevent drying unless you have a cold moist compartment. Green vegetables should be cleaned and wrapped in paper or placed in covered trays or jars in the refrigerator. They will then keep fresh and crisp.

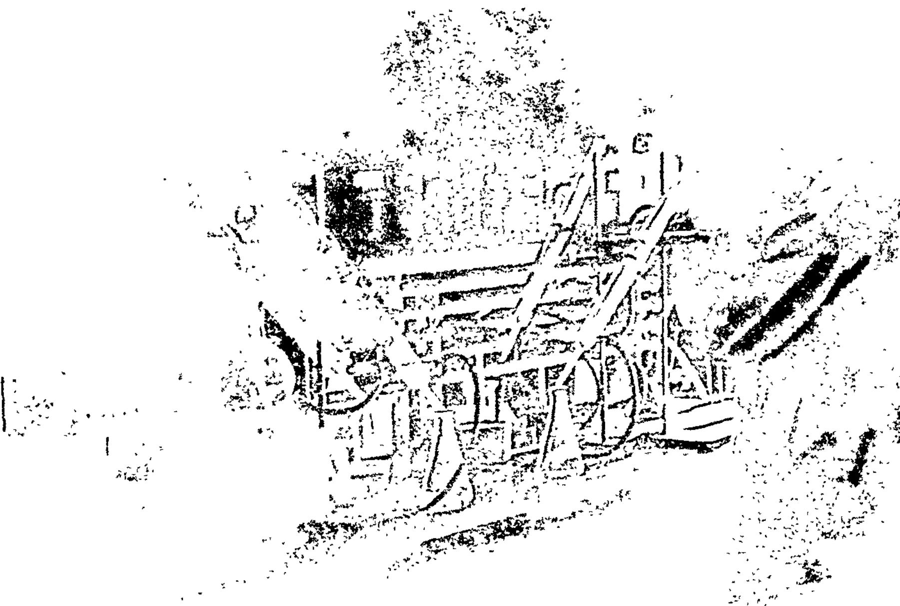
GENERAL PROBLEM 4

Why Is Food Protection Health Protection?

PURE FOODS AND DRUGS.—Milk needs great care in handling because it is so favorable for the growth of germs. Typhoid fever in the family of a careless milk producer has been transmitted to other families where milk from his dairy has been distributed.

Testing Milk.—Good milk distributing companies have laboratories where their milk is constantly being tested. It is necessary to keep a careful check on all the milk that is distributed. If infected milk were sold, the results could be very serious.

The Borden Company



Raymond E. Hanson

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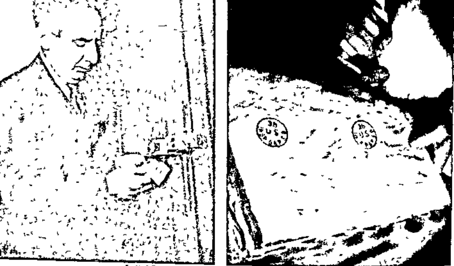


United Press Associations U S Department of Agriculture

Unclean and Clean —The Health Department inspector on the left is sealing the refrigerator in a delicatessen. The delicatessen failed to obey sanitary regulations The ticket on the door says, "Unclean."

The picture on the right shows the round purple stamp that means the meat came from a healthy animal Agents of our Department of Agriculture inspect and approve or disapprove the animals at the slaughter house.

for, food not only may spoil, but may even be the means of spreading disease germs Decay and spoiling of food are due to the action of bacteria, molds, and other organisms Foods may be preserved by making it difficult or impossible for the organisms to grow on the foods. Typical methods of preservation of foods depend upon heat treatment, cold treatment, or chemical treatment. Each has its special advantages for certain foods.

Key Words

alcohol
bacteria
circulation
cold storage
conduction
convection
drugs
energy
freezing
germs
heat transfer
humidity
insulate
membrane
mildews
molds
molecule
non-conductor
osmosis
pasteurize
preservative
pressure
"quick freeze"
radiant energy
refrigeration
sanitary code
typhoid fever
ventilation
water glass

Key Statements

1. The problem of food storage involves proper ventilation, proper temperature, proper humidity, and fresh quality of the product to be stored.

2. The preservation of fresh foods for long periods depends upon killing bacteria and molds, and upon sealing to prevent entrance of additional organisms. Or the food may be held at such a low temperature that organisms are inactive.

3. Foods may also be preserved by drying, smoking, or by the addition of chemicals that will destroy germs and molds and prevent more from growing.

4. The construction of efficient refrigerators depends upon a knowledge and an application of the principles of heat transfer.

5. Conduction is the transfer of heat from molecule to molecule of a substance. Conduction occurs most commonly in solids.

6. Heat is transferred by conduction more readily by some solids than by others.

7. Convection is the transfer of heat from one point to another by the movement of the heat-bearing molecules. Convection currents are due to unequal heating and occur most commonly in liquids and gases.

8. Hot bodies (usually solids) give off heat by radiation.

9. Radiant energy travels in straight lines. It is changed back to heat energy when it is stopped and absorbed by another body. It can be reflected just as light is.

10. Refrigerators are cool because the cold unit absorbs heat from the air.

11. In a healthful city, stores are sanitary and their foods are protected from dust, flies, and handling.

12. The laws pertaining to alcohol and other narcotics are observed in a healthful city.

13. Your health department is chiefly responsible for the health of your community, but you must do your part.

Thought Questions

1. How do the problems of conservation involve science and economics?

2. Why can fruits be kept without freezing at a temperature of 32° F. or slightly below, while potatoes will freeze at 32° F.?

3. Why is the humidity of the air a problem in the construction of cold storage rooms?

4 In canning fruit or vegetables, why is it important to seal the can?

5 What are the conditions favorable to the growth of bacteria and molds?

6 Explain why drying a food helps to preserve it.

7. Why will foods keep longer in cold air than in warm air?

8 Describe the construction of the walls of a good refrigerator. What determines the efficiency of the refrigerator?

9 Where should a food having an odor be placed in a refrigerator? Why?

10 Why is 50° F. the maximum air temperature of a good refrigerator?

11 You have seen refrigerating pipes in meat counters What makes them become covered with ice?

12 How is the preservation of food related to your health?

13 Why are food and drug laws necessary?

14 Why must the production and distribution of milk be carefully regulated?

15 Why should foods in stores be protected against flies and from handling?

16 What can you do to coöperate in maintaining a healthful city?

Projects for Your Science Discovery Book

1 Visit a cold storage plant and write an account of your observations. Tell what foods you saw and how the temperatures were controlled.

2 Make a report on the relation of moisture to the spoiling of foods

3. Make a collection of labels from canned foods to find which ones contain special preservatives Note which substances are used and how much

4 Make a diagram of a heater in a room and indicate by arrows the direction in which the air will circulate

5. Make a study of refrigerators and sketch a diagram of an efficient refrigerator wall.

6 Discuss the various methods used in canning fruits at home

7 Obtain samples of dried foods and experiment with them to learn how much water they will absorb

8. By visiting a fruit store, determine good methods of packing fruit.

9 Study the cold pack method of preserving vegetables

10. Study the effect of low temperatures on the keeping of apples by selecting two apples nearly alike and placing one in the refrigerator and one in the kitchen. Examine them from day to day for at least two weeks.

11. Build an ice box, insulating it properly. Test its efficiency.

12. Determine the temperatures and humidity of the air in a refrigerator.

13. Devise and work an experiment to illustrate the conduction of heat.

14. Devise and work an experiment to illustrate convection currents.

15. Make a trip to your city health department to learn about its activities.

By LIFE photographer Andreas Feininger Courtesy TIME, I

Liquid Gold.—There are more than 1,000 derricks in this great
field in California. Someday we may come to the end of our oil
serves, but conservation now can postpone that day.

TOPIC XVII

Conservation of Natural Resources

DO YOU KNOW—

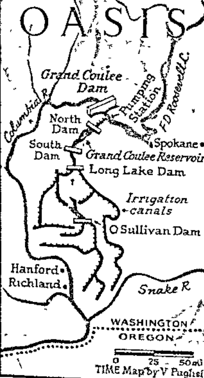
1. How top soil may be carried away?
2. Whether there are any important natural resources in your region?
3. Why natural resources must be conserved?
4. That our common fuels are "stored sunshine"?
5. What your part is in conservation?

GENERAL PROBLEM 1

How Can Land and Water Be Conserved?

NATURAL RESOURCES.—"Two billion acres of land within the United States; the rain and snow that fall on this land; the rivers, waterfalls and lakes; the coal, oil, gold and silver, and other mineral deposits that lie on and beneath the land; the people that live here and their multitude of talents, skills, and activities—these are our natural resources." This statement by the National Resources Planning Board tells us plainly what our natural resources are. These are our resources. Your problem as a citizen and a young scientist is to help conserve the resources.

CONSERVING SOIL AND WATER.—The conservation of soil and water has become one of the most important problems of our nation. From the time the first settlers came to this land up to the present, millions of acres of fine farmland have been ruined by erosion—especially by water and wind. Millions



Columbia River Reclamation Project—This map shows one of the huge desert regions which our government is turning into good farm lands and power projects

and millions of acres of valuable top soil have been swept away by wind and water.

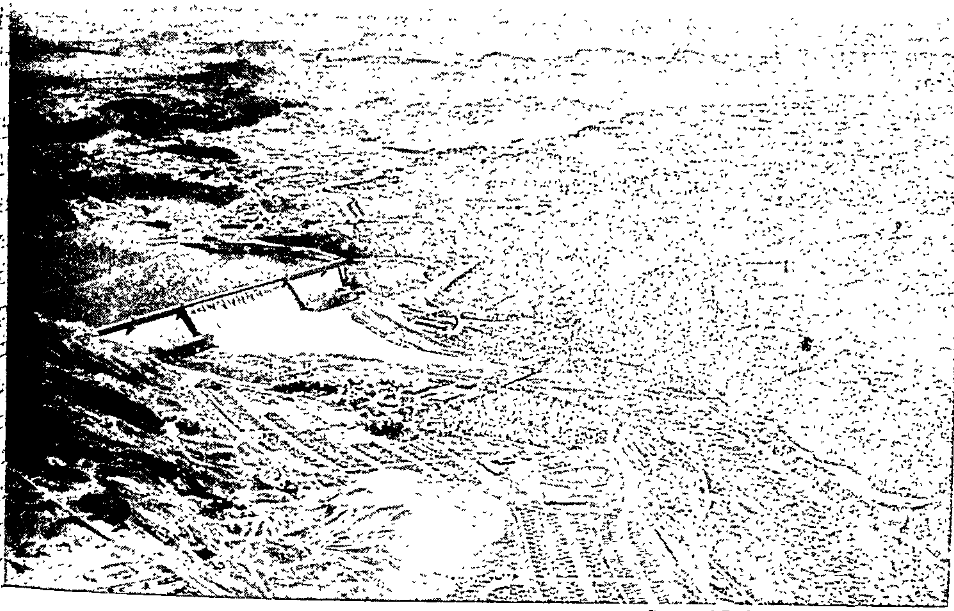
We know that top soil furnishes minerals for plant growth. When the top soil is gone, the land is worthless. Nature requires a long time to replace the top soil. Several centuries may be required to build just one inch. Yet during the past 150 years, top soil has been ripped from about 100 million acres of cropland. Another 100 million acres have been seriously damaged. And still the damage continues.

It is estimated that every year enough soil is blown or washed from American fields to fill a train of freight cars 390,000 miles long—a distance from the earth to the moon and more than halfway back again.

Our government is working hard to stop soil erosion. Farm agencies show farmers new practices to hold soil Great dams are being built to control flood waters and save land from floods The stored water is later distributed to grow more crops. The picture opposite and the map on this page show one of the newest projects for reclaiming desert land

The Soil Conservation Service has planted strips of trees to break the force of winds sweeping across the plains. Experiments are being tried in which airplanes are used to scatter grass seeds over hundreds of acres. Farmers are being shown how to plant the slopes to prevent erosion; they are being shown how to conserve the fertility of that soil; they are being shown how to keep gullies from starting.

One hundred fifty years ago much of our land was covered with thick forests and heavy carpets of grasses. As the forests



Bureau of Reclamation

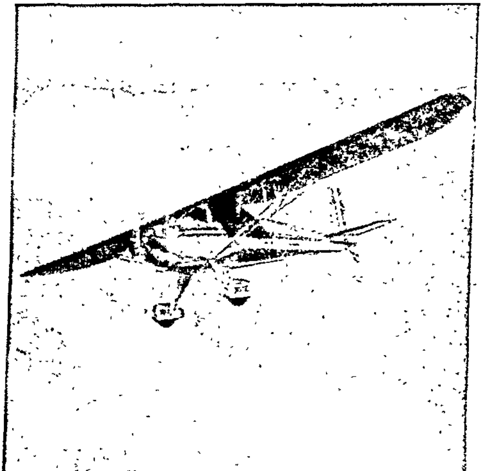
Grand Coulee Dam.—Use your mind's eye to fit this picture into the map on the opposite page.

were cut and the grasses plowed under, the soil was free to be carried away. But water as well as soil was affected. The grasses and forests held the rainfall, and allowed much of it to soak into the ground. The runoff was slow and quite steady.

Making Rain.—This young man is a partner in a "rain-making service." Here he is dumping dry ice from his plane to produce rain where it is badly needed. Note his oxygen mask. The other picture is a long-shot of a rain-making plane.

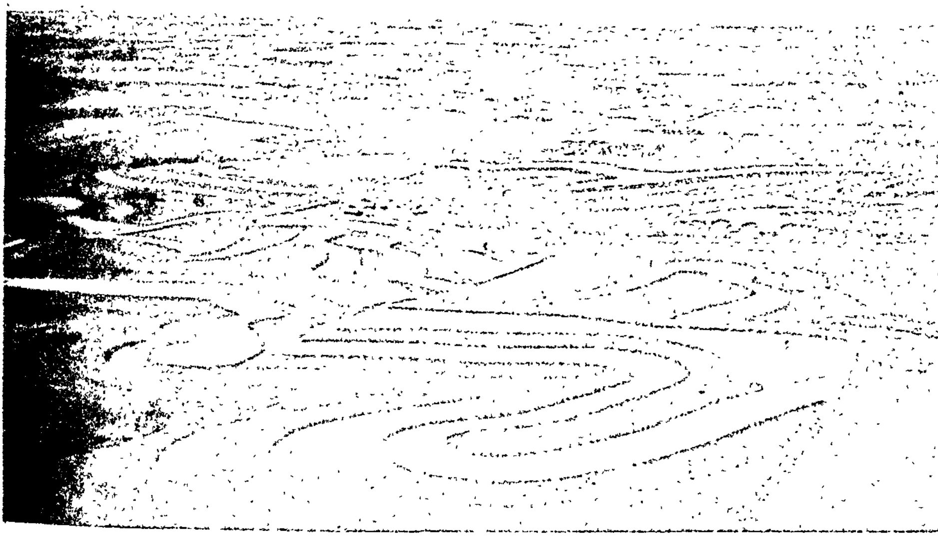
Wide World Photo

Courtesy Luscombe Airplane Corp.



Soil Conservation Servic

Saving the Land.—The upper picture shows a field without enougl
trees to hold the soil Erosion is taking place rapidly, and in time al
the good soil would be gone The bottom picture shows the sam
field three and one-half years after the planting of black locus
trees. Wasteful soil erosion has been stopped, and valuable lan
has been saved.

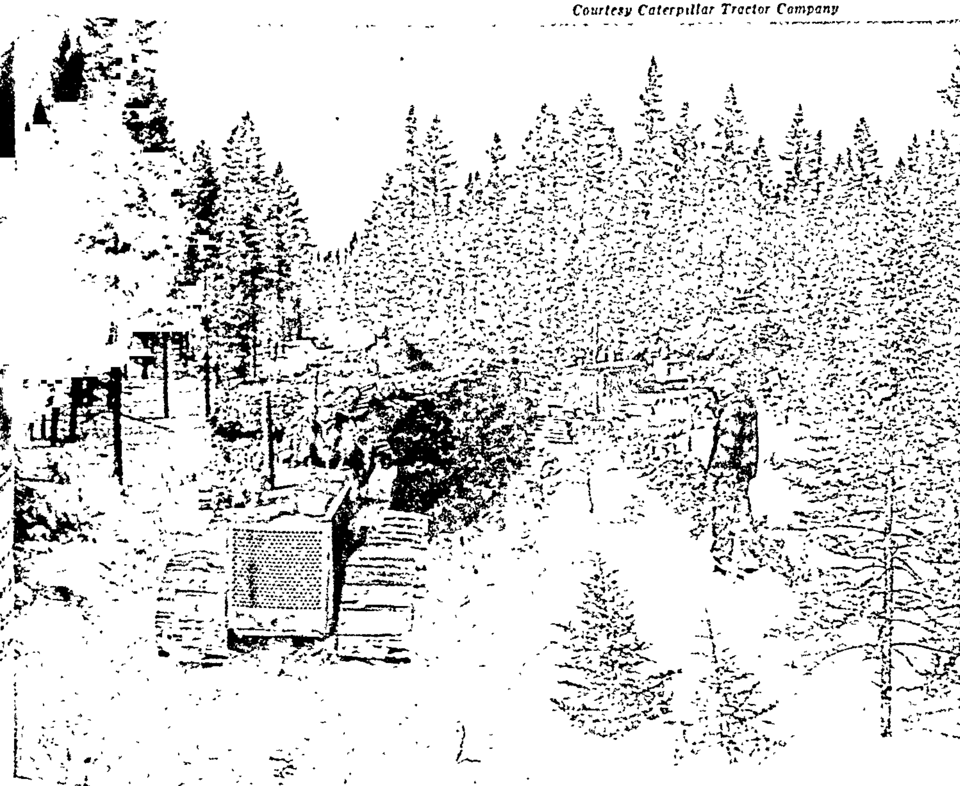


Parma Tysen

Conservation at Work.—Soil conservation is good for the land. It is also good business. Can you explain how?

Preparing for Christmas.—If new trees are planted to take the place of the ones cut, we shall have the forests to hold our soil.

Courtesy Caterpillar Tractor Company



With the grasses and forests gone, the rainfall quickly runs off to the nearest stream or river. As a result, less rain soaks into the ground, and the water table falls. In many parts of the country, the dropping of the water table in recent years has been serious. Wells have dried up. But more important, there has not been enough moisture in the soil to support plant life.

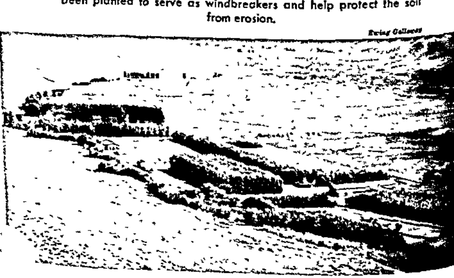
Recently rainmaking experiments have been tried in an attempt to increase the rainfall in a region. It is not yet known whether these experiments will be completely successful. In any event, the best way to conserve soil water is to return as much land as possible to forest or thick grasses.

WHAT YOU CAN DO.—The problem of soil conservation does not belong to the government alone. It is your problem, too, even though you live in a city. Perhaps erosion is going on in fields or lots near your home. You can take steps to stop it. You can also do your share by helping to support the conservation plans of your own community and state.

Most of all you can help by being well informed about the problem. If you live on a hilly farm, it is your duty as a good citizen to know how to plant and cultivate a field—around the slope (contour planting)—not up and down. You can plant crops that help the soil absorb or soak up rain water instead of making it easy for the water to run off over the surface.

Smart Forestry.—Scientific knowledge is improving this ranch in Argentina. The region is naturally treeless, but groups of trees have been planted to serve as windbreakers and help protect the soil from erosion.

Ewing Galloway



You should also know about strip planting—a practice of planting strips of different crops around a slope. Some of the strips are planted to grass crops, especially valuable in holding the soil. With this method the soil is kept from being washed down the hill.

Conservation concerns every citizen. Some 2300 soil conservation districts have been formed throughout our nation. Is there one in your region? Are you coöperating with it?

GENERAL PROBLEM 2

How Can Wild Life and Vegetation Be Conserved?

PARTNERS: WILD LIFE AND VEGETATION.—The cost of soil erosion in the United States has been estimated at 4 billion dollars annually. This amount, however, does not include the loss of wild life that has resulted. If the soil is ruined, vegetation follows. With the loss of vegetation, muskrats, beavers, raccoons, and other wild life disappear.

It is curious how these things all depend upon each other. It is what is called the balance of nature. Man has upset the balance by permitting overgrazing of the land by cattle or sheep, by cutting or burning the forests, and by draining swamps. When man upsets the balance, he is indirectly destroying helpful insects, birds, and animals.

ABUNDANCE.—When the first settlers came to this country 300 years ago, they found dense forests and fertile plains. Wild life seemed to exist in unlimited numbers. Have you read of the thundering herds of bison and the endless clouds of passenger pigeons? Ducks in migration stretched on for days and weeks. Where have these animals gone? The wild life only *seemed* to exist in unlimited numbers. Hunting killed off many. Draining swamps destroyed breeding grounds. Cutting forests took the homes of some. Lack of food killed others. Thus their numbers dwindled. Today there are no passenger pigeons. There are no heath hens. The bison barely escaped the same fate.

Science to the Rescue.—Now we understand that all wild life has natural enemies. We must not reduce the numbers too much or the natural enemies will kill off the rest.

We know the kind of breeding places needed by various forms of wild life, and sanctuaries have been provided. We also know, however, that breeding and stocking of forest and stream will not do the job alone. Natural homes and preventing hunters and fishermen from taking too much game are more important.

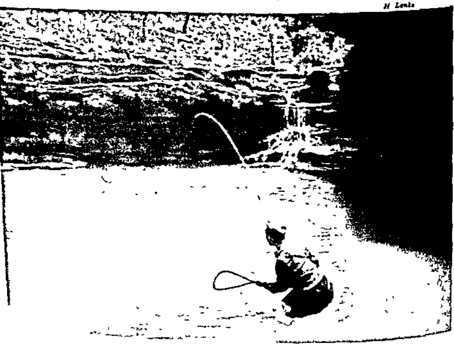
Modern sewage and garbage disposal plants and proper utilization of industrial wastes are protecting fish in many of our streams. All should be protected. Only then shall we have fish in abundance again.

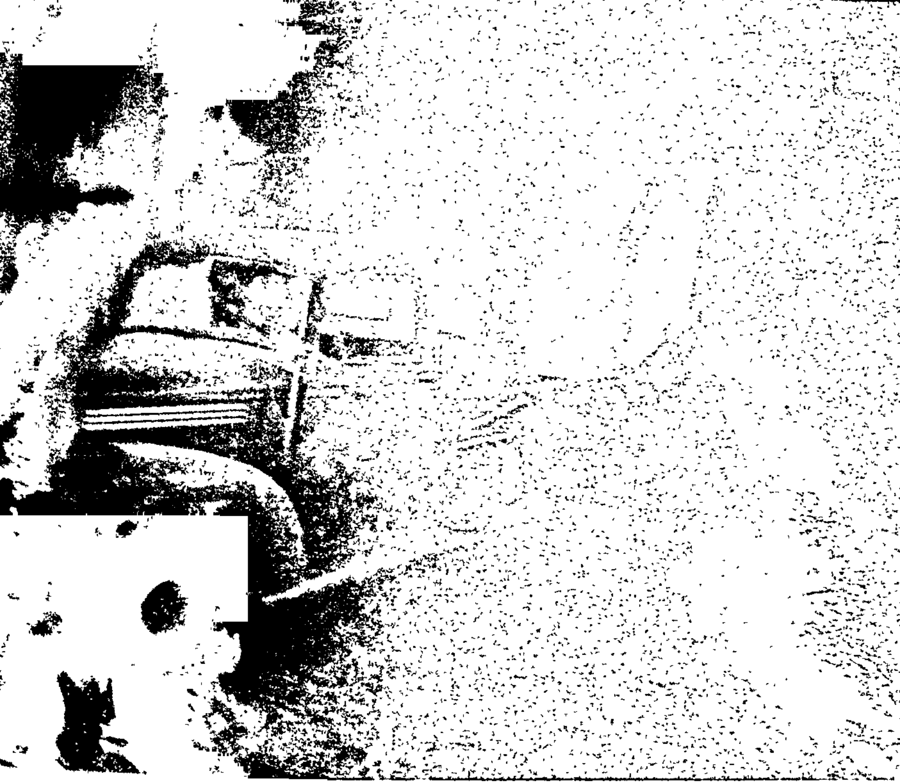
Fires, largely the result of carelessness, have destroyed millions of acres of forests and left the wild life to starve and die. Now modern methods of spotting fires and controlling them are gradually mastering the demon fire.

What You Can Do.—Whether you live on a farm or in a city, conservation of wild life is your job. When you pass

Trout Fishing—When nature is in balance, hunting and fishing are at their best. Good conservation practice means limiting the fishing season, and stocking the streams to replace the fish removed

H. Lenke





Are You Proud of This?—This scene of horror has resulted from someone's carelessness. A careless camper, a careless smoker may have started this. Study this picture. Remember it well. Resolve now to prevent such destruction.

wildflowers in the forest or field do you resist the urge to pick them? As a science student you know that flowers make seeds for new plants. If the blossom is picked, no seeds will be formed. Are you able to hunt with a camera and notebook rather than with a gun? Many real sportsmen find more pleasure in watching wild life alive than in carrying it off dead.

Are you doing your part to help prevent forest fires? Marvelous fire-fighting equipment has been invented, but it is better to prevent a fire than try to fight one. During the past five years, some 75 million acres of forest land have been destroyed by fire. Matches, campfires, and smoking are always dangerous in a forest. Never guess about a fire in the forest. *Be sure it is out.*

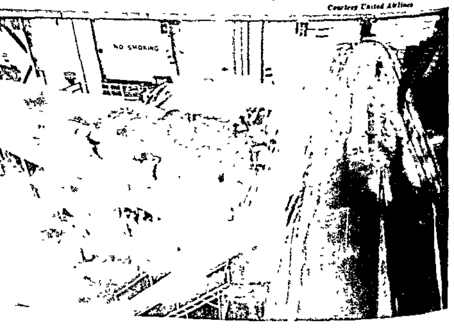
How Can Minerals Be Conserved?

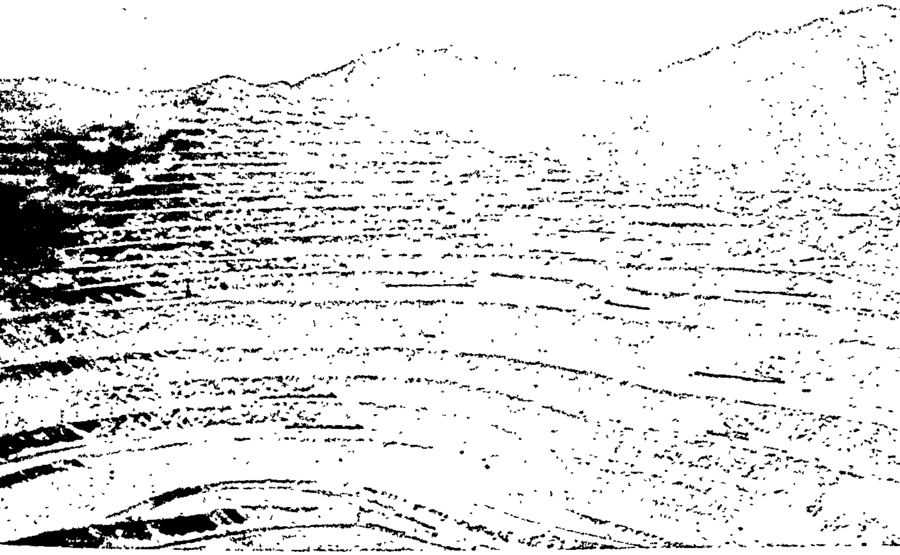
OUR USE OF MINERALS.—We are living in the Industrial Age. We sometimes call it the Steel Age because of our great dependence upon iron and other minerals. Have you ever thought about the minerals you use every day? Most important, perhaps, is iron, which is made into steel. How different our lives would be without steel! No trains, automobiles, tractors. No bicycles, radios, skates. No watches, airplanes, ocean liners Our modern way of living would be impossible without iron and steel.

Other minerals, though not so common as iron, are also of great importance. Some, added to iron, produce various steels—hard and brittle, or soft. Aluminum is a metal that became vital with the development of aviation. Why? In recent years greater quantities of aluminum were needed than ever before. This led to the development of a process which extracts aluminum ore from certain clay soils. Another light, tough mineral

More Precious than Gold—Our country needs tons and tons of aluminum to make planes for defense and for commercial purposes. This picture shows only part of just one of the hundreds of planes we manufacture each year.

Courtesy United Airlines





Buried Treasure.—This open-pit copper mine is in Bingham, Utah. Open-pit mines are both safer and cheaper to work than underground mines. The thicker the deposit of ore, the more "benches" or "terraces" are used to mine it. Note the railroad trains which carry the ore away.

is magnesium. It has made its way into lightweight ladders, wheelbarrows, lawnmowers, etc. Magnesium is now extracted from sea water. Copper, silver, gold, gypsum, lead, salt, tungsten, zinc, chromium, nickel—the list of useful minerals is almost endless.

Our Mineral Resources.—The Mesabi Range in Minnesota has for years produced most of the iron used in our country. Its ore is rich—about 51% iron. Its ore lies near the surface of the ground, so it was easy to get and ship to the blast furnaces. By the close of World War II it was realized that the Mesabi reserves were rapidly dwindling. At the present rate of use, there would be ore for only a few years.

Fortunately new deposits of high grade iron ore have been discovered recently in Labrador and Venezuela. There will be great problems of transportation, but the ore is there.

There is another iron ore on the Mesabi Range. Its name is *taconite*. It is only about 25% iron, but there are billions of tons of it available. For years scientists have searched for a

Kronfeld

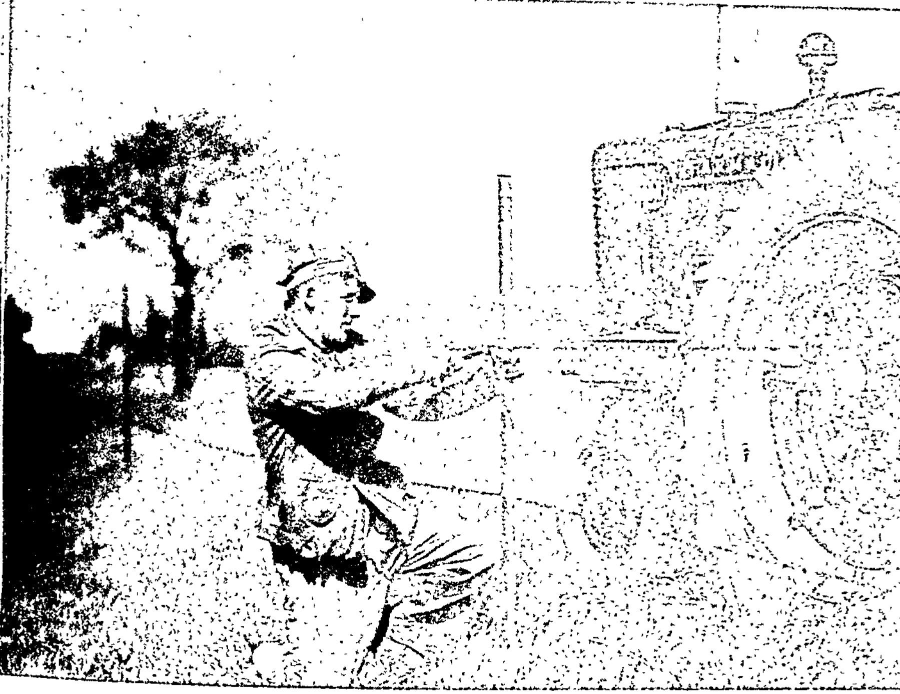
Mesabi Range.—This vast range has produced most of our iron ore for many years. Its rich ore has provided us with the iron from which many of our steel products have been made. Newer processes now give hope of using the billions of tons of *taconite* available on the range.

practical way to obtain the iron from taconite. At last they have been successful. A plant is now being built to prepare the ore for blast furnaces.

The story of iron ore has a happy ending. But we should remember that the high grade deposits in Venezuela and Labrador, and the taconite deposits are limited. Ore taken from the ground can never be used again. And this is true of other minerals as well as iron.

Although we have huge deposits of copper, gypsum, sulfur, lead, zinc, and other metals, we cannot afford to waste them. At the present rate of use, our zinc and copper reserves will last only about 15 years. Of course, more deposits may be discovered, but we should not plan on that. It is better to conserve, that is, use wisely, what we have.

What Can You Do?—The most important thing you can do in conserving minerals is to take care of metal objects and equipment. Particularly, you can apply your knowledge of corrosion and rusting. You know that moisture and air combine



A. Gould

Conserving Property.—The successful farmer knows the importance of keeping his equipment and property in top condition. "An ounce of prevention is worth a pound of cure" is an important idea in conservation. Do you think this man is a good businessman as well as farmer?

to attack metals. You know that some metals are attacked by acids in the air.

Both rusting and corrosion can be prevented to a large extent by keeping the surface of the metal free from moisture. You should wipe off garden tools, skates, bicycles, and other metal equipment before putting them away. Farm equipment should be taken care of if it is to last. Whenever possible, harrows, plows, rakes, mowing machines and other equipment should be stored in barns or sheds when not in use. All painted surfaces should be kept free of rust by frequent painting. Moving parts should be lubricated with oil or grease to keep them operating smoothly. Proper care takes time. But it saves money and minerals in the long run.

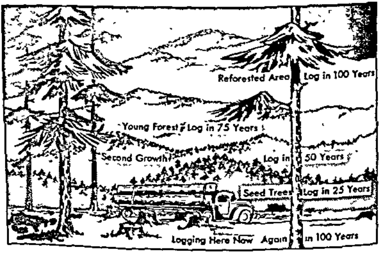
Thousands of scientists are helping you conserve minerals every day. As in the case of taconite, they are discovering new ways to refine ores. Scientists are also discovering more substitutes for metals. All of us know about the wide use of plastics for toys, handles, lamp stands, clocks, and a variety of other uses.

GENERAL PROBLEM 4

How Can Fuels Be Conserved?

SIFTING THE ASHES.—Do you know how to care for a stove or a furnace? If so, do you watch the ashes to see if you are wasting coal? Years ago, many people sifted the ashes to save the partly burned coal. Some people do this even now. It is a good idea, but it is a better idea to regulate the fire so that the coal is all burned the first time.

FOUR FUELS.—There are four common natural substances used for fuel: wood, coal, oil, and natural gas. Each fuel has its advantages and disadvantages, depending upon where a person lives. But the problem of which fuel to use is not so



Tomorrow's Timber.—This diagram shows how intelligent forestry can provide for the future. The captions show you how the whole area has been divided into sections, with a definite time set for logging each section. This arrangement means that there will always be new trees to replace the ones cut down.

important as learning how to use that fuel in an efficient manner.

If there were unlimited amounts of fuels, it wouldn't make much difference whether people saved or wasted them. But fuels are not unlimited.

WOOD.—Once this country seemed to have an inexhaustible supply of timber for lumber, for fuel, and for all sorts of wood products. Now we know that is not the case. By careful planning and scientific forestry, we may have enough for our needs. But we certainly will not have any to waste.

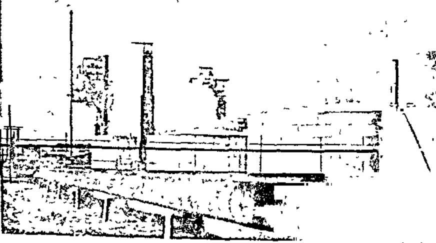
Today, good forest management is getting more and more out of each tree. As much as 70% of the entire tree may be used. Even shavings and sawdust are pressed into small "logs" and used for fuel.

COAL FROM ANCIENT PLANTS.—Coal is a mineral that took millions of years to form in the earth. Every pound of coal represents stored energy from the sun. It is energy stored by plants that grew in the early days of our earth. The trees used sunlight to grow and form wood. In time the trees fell to the ground and were buried under mud. Rock layers formed above. The great pressure and heat slowly changed the wood into soft coal, and then hard coal. Thus the coal mined today is energy that was captured by trees millions of years ago.

There are many deposits of coal in the United States. Scientists think that there is enough coal to last for many generations. But that does not give us the right to waste it.

Coal is often wasted at the mine. It is frequently wasted at the factory and in the home. By building more efficient furnaces and stoves, science is helping to save coal. Buildings are insulated so that less heat is required to heat them in the winter. All these ways help to conserve fuels.

Recently scientists have been experimenting with burning coal underground. This may seem like a wasteful thing to do. Actually it is a conservation measure. Some mines have a poor quality coal. Or it may be difficult to take the coal from the mine. By regulating the amount of air entering the mine, scientists can burn the coal and collect the gases formed. The gases may then be separated. Some of them may be used as fuel. Others are valuable as raw materials in chemical plants.



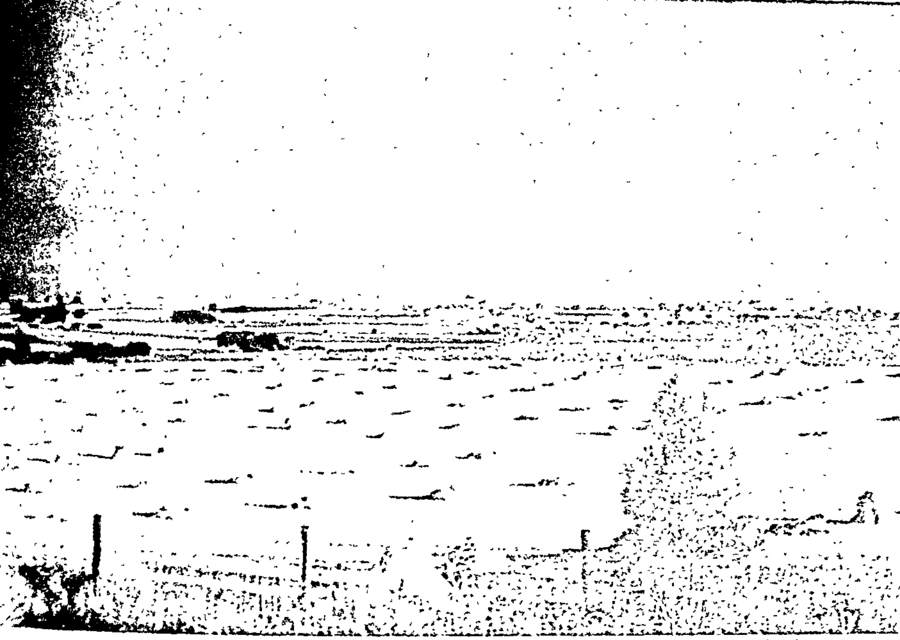
Courtesy Standard Oil Company (New Jersey)

Refinery.—In refineries such as this liquid gold—petroleum—is changed into gasoline, kerosene, and gases with scores of uses. The tall structures in the background are towers where petroleum is distilled into its parts or fractions The tanks in the foreground are used to store the various products. Why are the tanks painted white?

As yet this has been done only on an experimental scale. If it proves to be successful, it may become a common way of "mining" coal.

OIL—LIQUID GOLD.—The story of oil is one of over-supply and misuse and waste. No one knows exactly how great the oil reserves are in our country, but most scientists believe the supply is limited. If oil is wasted, we may exhaust our supply within a generation. Oil is so important in this day of machines that scientists have searched throughout the world for new deposits. Alaska, South America, and even the rocks under the oceans have been explored for oil. In recent years *shale oil* has been produced from shale rocks in Colorado. So far the production of shale oil is not practical. But it may be necessary to use it if our other supplies fail.

Scientists are also helping to conserve oil by inventing equipment that burns oil more efficiently. Modern oil burners



R. H. Freed

Amber Waves of Grain.—This is beauty, poetry, and music. This is America: a land which provides bountifully for its people, a people who love their land and know how to care for it.

are made so that they mix the proper amount of air with the oil to obtain the correct combustion.

NATURAL GAS.—Natural gas is another of nature's products that have taken millions of years to make. Gas, like oil, has been wasted in enormous amounts. Now, however, it is being conserved. Natural gas from Louisiana is carried by pipes to Atlanta and St. Louis. Gas from Texas is piped to Chicago and Minneapolis, and even areas as far east as New York State are now receiving natural gas through pipe lines. Who knows, perhaps some day almost every town will have natural gas from the great sources in the south central part of our country. The more uses there are the less our fuel must be wasted.

WHAT YOU CAN DO.—Fuel conservation, as with conservation of all resources, is everybody's job. We know that scientists are helping by discovering new deposits and new methods of obtaining fuels. Our government is helping by enforcing laws for good conservation practices in the forests, and at the mines and wells. You can help by applying what you have learned about fire and its control. You can make sure that fuels are being burned efficiently in your home. You can understand why conservation laws are needed, and obey the laws. Most important, you can be informed about the problem of fuel conservation, and have a scientific attitude about it.

THINKING THINGS OVER —This whole topic is intended to help you think things over. Look back in your book and your Science Discovery Book to discover the many details about conservation which you have studied. The time to think about conservation is not once a year but every day. Conservation in little things adds up to conservation in big things when on a nation-wide scale.

Everything you use needs to be conserved. Paper, pencils, ink, fabrics, leather, sugar, foods of all kinds, wheat, oats, and countless other articles must be conserved. Only with an abundance of these things can we have healthy, happy lives. With an adequate supply of natural resources and an understanding of nature's laws, there is no limit to man's progress.

KEY WORDS

balance of nature	mineral
breeding season	natural resources
conservation	polluted
contour planting	scientific forestry
corrosion	shale oil
insulated	strip planting
Mesabi Range	taconite

KEY STATEMENTS

1 Land is conserved by preventing erosion

2 Contour and strip planting help to prevent erosion of soil

3 Water is conserved by preventing floods.

4 Shelter belts of trees help to prevent wind erosion and conserve water.

5 Loss of vegetation is followed by loss of wild life and then by loss of soil

6 Man often upsets the balance of nature.

7 Scientific discoveries aid in conservation

8. Corrosion of metals, a form of oxidation, is a cause of waste

9. Man-made plastics may be substituted for some metal uses.

10. There are four common natural fuels—wood, coal, oil, and natural gas.

11. Energy from burning wood, coal, oil, and natural gas represents energy from the sun stored by plants millions of years ago.

12. Conservation is a responsibility of everyone.

Thought Questions

1. Why is coöperation necessary for the best conservation of soil?
2. How is vegetation, including forests, related to the conservation of our water supply?
3. How is erosion prevented by contour or strip planting?
4. How are wild life and vegetation partners in conservation?
5. How can corrosion be retarded or prevented?
6. Why are the hills not everlasting?
7. How is it that the heat from burning fuels represents stored energy from the sun?
8. What is meant by *scientific forestry*?
9. Make a list of any five articles in school or at home. Opposite each write the natural resource or resources that make it possible.

Projects for Your Science Discovery Book

1. Write to the Soil Conservation Service, U. S. Department of Agriculture, for bulletins on soil conservation for your section of the country. Read the bulletins and then make plans to help save your soil.
2. Make a survey of the soil erosion problem in the yards of members of the class. Work out ways to improve the situation.
3. Look up information comparing amount of forested lands in the United States during Colonial days and now. Try to explain the causes of the differences.
4. Read about the days of the bison herd and passenger pigeon. Try to account for the near destruction of the bison and the complete destruction of the passenger pigeon.
5. Look up information about the pollution of streams and its effects. If streams in your neighborhood are being polluted, try to arrange plans to stop the pollution.
6. Write to your state capital for information about the important minerals produced in your state. Study conservation methods in use.

7. Someone in the class might investigate plastics that are used as substitutes for metals. What metals? What are the raw materials used in making the plastics?

8. Investigate and report on the conservation methods used in mining coal.

9. If you live near gas or oil wells, report on conservation methods used.

10. Write a short story to explain how a village may become deserted as a result of lack of soil conservation. Select a good title for your story.

Observers' Club

Young scientists find it interesting and helpful to organize an Observers' Club. Such clubs have officers whose duties are like those of officers in other clubs. Every member in an Observers' Club, however, contributes all he can to the club activities. Each member is on the alert for new things to observe, new facts to discover, new studies to make.

If your class wishes to organize an Observers' Club, arrange with your teacher for election of officers. Start as early as possible to prepare a program of the year's activities. Plan a schedule of meetings, arrange for a workshop, and prepare for as many different field trips as you can.

Above everything else, plan to make your club a conservation club. Know exactly what conservation means and how it applies to your community. Then do something worth while for conservation where you live.

ORGANIZATION

I. Chief of Staff, and Assistant Chief of Staff.
  A. Chief Health Officer, and Assistant.
  B. Chief Observer, and Assistants as follows:
    1. Weather Observer.
    2. Astronomical Observer.
    3. Bird Observer.
    4. Plant Observer.
    5. Geological Observer.
    6. Others as needed.
  C. Chief of Scientific Methods, and Assistant.
  D. Chief of Records, and Assistant.

II. Duties of these officers shall be those indicated by their titles. Some suggestions follow. Notice that duties suggested for one officer often suggest similar duties for another.
  A. Chief of Staff.
  This officer will announce and conduct meetings of the members of his staff as he and the staff may plan them. At these staff meetings the general business of the club should be cared for.

B. Chief Health Officer.

1. This officer shall be responsible for adjusting the shades in the clubroom (classroom) for the proper control of light.
2. He shall observe and record air temperature in the room when he enters and make adjustments if they are needed.
3. Each day he shall make observations and records of the general properties of the air, such as dustiness, odors, and humidity.
4. He shall have charge of such duties as the hygienic care of books and laboratory supplies.
5. He shall be responsible for health charts and records.

C. Chief Observer

1. This officer shall direct the meetings of his division.
2. He shall see that reports of desirable observations are made and that charts and records of such observations are posted.

D. Weather Observer

1. This officer shall record the club weather observations and make charts for them. Such records shall include temperature, wind direction, wind velocity, condition of the sky, whether it rains or snows.
2. The records shall also include all special observations (e.g., a ring round the moon) which may be reported by different members of the club.

E. Astronomical Observer

1. This officer shall make charts for recording star observations.
2. He shall watch for newspaper and magazine reports of astronomical events and keep the club informed in advance of such events.

F. Bird Observer

1. This officer shall prepare charts for recording reports of birds seen and identified by any and all club members.
2. The charts shall record the name of the bird, date when seen, where seen, what it was doing when seen, and the name of the observer.
3. No bird should be recorded as having been seen unless the observer supplies good evidence that the bird reported was actually seen.

G. Plant Observer

1. This officer shall provide charts, sketches, snapshots, specimens, and similar records relating to small plants, shrubs, trees, and greenhouse exhibits in the park or school greenhouse.
2. He shall investigate interesting opportunities for observations of plants in the community and report them to the club.

H. Geological Observer.
1. This officer shall arrange exhibits of rocks and minerals.
2. He shall search out and report interesting geological formations which may be visited by the club.
3. He shall arrange exhibits of fossils and assist in the identification of fossils and other geological specimens.

I. Chief of Scientific Methods.
1. This officer must be a straight thinker, accustomed to thinking things through. It shall be his special duty to see that statements made by the club members are accurate and that opinions are based on sound evidence.
2. At the request of the staff, he shall be ready to assist in the examination of notebooks to check for thought and method.

J. Chief of Records.
1. This officer shall serve as recording and corresponding secretary.
2. At the request of the staff, he shall assist in keeping records of club members in their science work.

III. All meetings shall be conducted according to standard rules of order.

IV. Any member or officer who fails to live up to the duties of membership or office shall be subject to a hearing and removal by majority vote.

Calendar

September Observations

STARS.—Star observations are best started by reference to the North Star, Big Dipper, and other constellations of the northern sky. These are the guides by which we may locate other stars. They are convenient because they are always above the horizon.

When does the September Equinox occur? Is it the same all over the world? What conditions cause the equinox? This is a job for your chief astronomer.

PLANETS. Are there any planets to be seen among the stars around the pole? Why? Where should one look for the planets? Near the paths of what two celestial bodies? What planets are visible in September? The planets that are visible to the naked eye are Mercury (with difficulty), Venus, Mars, Jupiter, and Saturn.

Note each planet's course among the stars and the times of its rising and setting.

An almanac, the newspaper, or some magazine like the following are good places to look in order to learn what planets are visible each month and where to see them:

Sky and Telescope. Sky Publishing Corp , 91 Huguenot St., New Rochelle, N. Y.

Science News Letter. Science Service, Inc., 1719 N St , N.W., Washington, D C.

Nature Magazine. American Nature Association, Washington, D C

WEATHER —Observe your local weather conditions daily, and then check against the weather forecast as published in the newspaper. To become a good weather observer you will need to observe and record the wind direction and velocity each morning or afternoon. Note the condition of the sky, the kinds of clouds, and the kind and amount of precipitation Learn the different weather symbols found on the weather maps and use them to record your observations.

Of course, you will keep your ear open for weather sayings and signs, and check their accuracy.

PLANTS —Bring plants into the laboratory for fall and winter study. Geraniums, begonias, coleus, snapdragons, and ferns will be useful. The Plant Observer will see that the plants are cared for properly.

ANIMALS —Many birds migrate during the fall months. The Bird Observer should have charts ready to record arrivals and departures of birds Other habits such as singing, feeding, flying, and perching may also be observed and recorded

Gardeners will be interested in insects, toads, and snakes in their gardens

How about a rat-extermination campaign, if one is necessary?

SPECIAL ITEM —Plan to collect and display farm and garden products on your Science Discovery Table Each product should be correctly labeled Perhaps fruits and vegetables grown by class members can be displayed and prizes given as at a county fair. The display might also include seeds of the various plants

Plan a Science and Engineering Fair to be held in the spring. Write Science Service, Inc. for help.

October Observations

STARS —As you continue your star studies, observe especially the Milky Way Where is it? What is it? What importance has the Milky Way?

Begin to look for "shooting stars" (meteors) Which star has to do with the times of sunrise and sunset? Since the equinox, the days are growing shorter and the nights longer. Why is this? Make a graph on the blackboard to show the sunrise and sunset times for this month. Are the days changing in length more in the morning or in the evening?

Try to locate The Swan (The Northern Cross) and Deneb, its brightest star. Try also to locate other fall constellations such as the following:

The Scorpion is in the opposite part of the sky from Orion. The first magnitude star Antares is a bright red star.

The Archer is far to the south, lying in the Milky Way.

Aquarius, the Water-Carrier, contains four stars which form a Y and mark the water jug.

Boötes, The Bear Driver, contains the bright star Arcturus. The Northern Crown is a circlet of seven stars, one brighter than the rest.

Aquila, the Eagle, is the constellation with the very bright star Altair. There are bright stars on each side of Altair—three in a row—which will help you find Aquila. You will be interested to read the legend about Aquila.

Lyra, the Harp, with its bright star Vega, can be seen during the fall and also in May, June, and July.

PLANETS.—Continue the observation of planets discovered last month if they are still visible. How have their positions among the stars changed? Are any planets visible now that were not visible last month? Is there an "evening star"? What is it?

WEATHER.—What is your north latitude? When do you expect the first killing frost? Is that the end of your growing season? Why?

Continue making weather records and practicing weather forecasting.

Are the days gradually growing colder? How much on the average? Explain what is happening to cause the change. Does the average wind direction change as the temperature changes? Why?

PLANTS. Do the leaves of the broad-leaf trees drop during the fall where you live? Or do they stay green for two years and then drop? What is an evergreen tree?

Do any of the following trees or shrubs grow in your vicinity? Which ones?

The Rose of Sharon	Sumach	Birch
Red Oak	Cornelian Cherry	Rhododendron
Poplar	Fire Thorn (cotoneastu)	Red Maple
Bittersweet	Beech	Iron Wood

Do their leaves show fall colors? They do in some parts of the country.

Bulbs for winter forcing may be brought in now. It is a good time also to make green wood cuttings from roses, hydrangeas, and forsythia. Such bulbs as hyacinth and narcissus should be kept cold for a few weeks after potting.

ANIMALS.—Try to find a toad in your garden. Where does the toad go during the cold months?

Which of the following animals live in your vicinity: prairie dog, gray squirrel, cottontail rabbit, prairie mole, spotted skunk, woodchuck? If some other variety lives near you, find out what variety it is. In any case, make a special study of the usefulness or harmfulness of at least one of the animals that makes its home near where you live.

Birds vary in different parts of the country, such as the robin of the north, and the southern robin. Of the following birds, find out which live mostly in one general locality, and which can be found almost everywhere in the United States: bobolink, bobwhite, prairie marsh (redwing blackbird), mockingbird, brown thrasher, flicker, red-bellied woodpecker, blue jay, chickadee, crow, raven, cardinal. Select birds from different localities and make comparisons of their habits and environments.

"Swat-the-Fly"—Why? How many kinds of flies can you find? How do they differ?

SPECIAL ITEM.—Plan now for Fire Prevention Week. If your town does not have a Fire Prevention Week, it will be a good idea for your science class to start one. Write to the National Board of Fire Underwriters and your State Department of Conservation for suggestions. Save property, labor, and lives by preventing fires.

November Observations

STARS.—Find Orion on a star map, and then try to locate it in the sky. Read about Orion and about the two great stars Betelgeuse and Rigel. How do they compare with the sun in distance from the earth, in size, temperature, and brightness?

Again locate the "Milky Way" and the constellation The Swan (Northern Cross) with its great star Deneb.

Late in November is a good time to watch for meteors. Why is the name "shooting stars" misleading?

PLANETS.—What's new in planets this month? Check the location of Mars and Venus. Is there a "morning" or "evening" star? What is it?

Do you know why the planets and moon appear to travel across the sky in about the same paths? Are the planets or the stars farther from the earth?

Try to locate someone who has a telescope and arrange to observe the planets and moon.

WEATHER.—Are the November clouds different in general from September clouds? Describe. Learn the symbols for the common clouds.

Do clouds at different heights travel in the same or different directions? What does this indicate about air currents? Which kinds of clouds are low, middle, and high clouds? Use "L" for low, "M" for middle, and "H" for high.

Keep up your wind direction reports on your weather chart.

Refer to the wind chart on page 49 for symbols to use in recording direction and speed.

In November early frosts are due in some parts of the country. Watch out for your plants. If you have learned to read a barometer, you will want to record air pressures also on your weather charts. What indications of weather changes, if any, can you observe from the activities of animals? Record them.

Check to discover if any local industry is affected by the weather changes.

PLANTS.—If you live in the north, and started seedlings in September, they probably need to be transplanted now. September cuttings also should be transplanted now.

Which of the following trees grow abundantly where you live? White pine, yellow pine, long-leaf pine, cherry, apple, pear, orange, lemon, grapefruit, banana (should this really be called a tree?), cabbage palmetto, cucumber tree, live oak, evergreen magnolia, tulip tree, cypress, maple (any kind), hemlock, spruce, arbor vitae, cedar? Select one tree which you can study at first hand and examine it for buds and branching arrangement.

Make a list of shrubs and vines that provide berries to feed the birds in winter. Compare vegetables and fruits grown where you live with those grown in other parts of the country. Try to discover reasons for any differences.

This is a good time to plan for your Christmas tree and decorations. There is danger of fire and you may wish to fireproof them. Leaflet 183L from the Department of Agriculture, *Fireproofing the Christmas Tree*, tells you how.

ANIMALS.—Continue your observations of bird arrivals and departures. Remember to put out food for winter birds when the snow may cover their natural feeding places.

Protect young fruit trees against damage by mice, rabbits, and other animals

SPECIAL ITEM.—Prepare now to avoid that cold. Get plenty of rest, exercise, and proper food. Do not neglect the vitamins. Do not over-eat. Neither should you eat too little as some do who want to keep thin. Avoid unnecessary crowds and keep away from people with colds.

December Observations

STARS.—Read about the Star of Bethlehem. Was it a comet, a nova (new star), a meteor, or three planets close together?

This month our closest star—the sun—starts "traveling north" again after the shortest day about December 21 or 22. From where you live, make a note where on the southwestern horizon the sun sets on that day and compare with its position when it sets next March 21 or 22. Explain what happens. If you lived on the equator or at the North Pole, where would the sun be on those two days?

Determine the direction of "true" north and the magnetic north. For which of these will you need a magnetic compass? How can you determine the other?

Observe the Pleiades, called also the Seven Sisters. Look again for Deneb and then for Vega. Which is larger? Farther away?

PLANETS.—What planets are visible this month? Learn about at least one planet you do not already know.

WEATHER.—The First Cold Spell; The First Snowstorm; That Big Blow; will make good topics from which to choose for a scientific article for your English paper, and for your science class, too. Whichever topic you select consider the weather factors involved. Discuss the weather in terms of *cause* and *effect*, that is the scientific way.

Compare your weather on December 25 with the weather in other places in the United States. Compare it also with the weather in Manila, Honolulu, and Fairbanks.

Identify three or four different kinds of clouds and try to photograph them. Label the photographs and put them in your Science Discovery Book.

PLANTS.—From the newspaper learn the wholesale market prices of some farm products.

What fruits and vegetables are being shipped into your town from other parts of the country? Why is this possible? Is it necessary?

If you have not completed your plans for winter flowers, refer back to November for suggestions.

Make a trip to a commercial greenhouse. However, do this before the Christmas rush.

Make a study of evergreens—trees, shrubs, and vines—used for Christmas decorations to determine if the needs for conservation are being observed. Consider especially American holly.

Do you know the story of mistletoe? If not, look it up and tell it as a Christmas story to your class.

During Christmas vacation, take a hike through the woods, open fields, or along a country road to study the trees and shrubs in winter. Note also grasses and weeds. Do any of these contain seeds? Do any of the plants furnish food for the winter birds?

ANIMALS.—Make a bird census on Christmas day.

The following bulletins available from the Fish and Wildlife Service, Department of Interior, Washington 25, D. C. may help you:

CB1, *Attracting Birds;* CB17, *Local Bird Refuges;* CB13, *Feeding Wild Life in Winter.*

If you have snow during December, go out into the woods and fields and find wild animal tracks. Photograph them or make sketches to illustrate. Tracks are better photographed with slanting rays of light which cause shadows. Be careful to make the correct exposure.

SPECIAL ITEM.—Investigate the heating and ventilating plant in your home and at school. How does the heat get from the burning fuel to the air in the rooms? Have in mind the three ways by which heat is transferred—conduction, convection, and radiation. Conservation of fuel involves proper combustion, and insulation of the roof and walls of buildings. Is fuel being conserved? Look for fire hazards. If you find any, do something to prevent fires. Make diagrams to illustrate your discoveries. Observe the fire escape nearest to your classroom.

January Observations

STARS.—Continue your study of stars and constellations. Learn some interesting facts about them.

PLANETS.—Are any of the planets that were visible last month visible now? If so, has their location among the stars changed? Draw their positions on your star map.

Do you want to make a telescope? If you do, write to the magazine *Sky and Telescope* for help or read about it in *Starcraft* by Barton and Joseph, published by Whittlesey House, McGraw-Hill Book Co.

WEATHER.—Morning and evening cloud forms and colors are most interesting to photograph, especially if you can use color film.

Do you believe that a "red sunset is followed usually by a fair day"? Check such observations with the prediction on the weather map or in the paper, and write what actually happens.

January and February are good months to keep weather records, using the chart found in your Science Discovery Book. Use the new symbols (see page 98) for recording weather facts.

Form a Weather Forecaster's Department of your science club.

The Educational Series of the U S. Weather Bureau is free to teachers and principals Others must pay a small fee:

The Educational Series contains. *Cloud Forms, Weather Forecasting,* No 42, *Explanation of the Weather Map; The Weather Bureau*

PLANTS —How do trees differ in their branching arrangement? Why do they differ? Winter is a good time to observe and make drawings of the ways trees branch

Bring in bulbs—narcissi, daffodils, jonquils. Send for your seed catalog and begin now to plan your garden Make a diagram of your garden Fruit trees and vines may be pruned now.

ANIMALS —Have you any winter birds about your house? What do they eat? Do you need to replenish the food counter?

If you have hemlocks near by, look there for chickadees.

Continue your study of animal tracks in the snow. Compare tracks of wild animals and birds, with cats, dogs, horses, cows, chickens, and turkeys if you can

SPECIAL ITEM —Do you know how sound travels and how fast? This is a good month to experiment with sound. Get some boy or girl from the physics class to help you

Here are some things you can do.

1 Note how much longer it takes for the sound of a steam whistle to reach you than for the light from the steam; or the sound of an ax after you *see* the blow
2 Find out how tightening a violin string affects the pitch. How does the pitch of a big string compare with that of a small (slender) string on the violin or banjo?
3 Use two empty tin cans and a long string or wire to make a telephone
4 Find a place where you can call and hear an echo Try to explain what causes the echo

February Observations

STARS —Make a chart and keep a record of the times of sunrise and sunset for the month Then on a piece of cross section or ruled paper plot the times from left to right. Are the days growing long faster in the morning or evening?

PLANETS.—What is the "evening star"? "Morning star"?

What planet is visible now that you saw last month? Again mark its position on a star map.

WEATHER.—Every day post a weather map from the newspaper on the bulletin board.

The Chief Weather Observer will have an interesting job this month tracing the paths of "highs" and "lows" across the country on a map of the United States.

Add another set of weather observations to your weather chart. Note especially the relationship between wind direction and cold spells.

Using the weather map, compare weather conditions in Southern California, Florida, Washington (state), Maine, and your home.

How about that cold? Have your Health Observer find out how many colds each member of your class has had so far this winter. Then try to discover why some have had more than others. What can be done to prevent colds?

Determine the temperature and relative humidity in your classroom each day for several days. If the humidity is too low, try to have it increased.

PLANTS.—Now is the time to start seeds indoors for outdoor transplanting. Such seeds as verbena, phlox, larkspur, calendulas, stock, and snapdragons are suitable. Seeds of bedding plants—petunias, and salvias—may be started now. Consult your seed catalog for others.

Try some of your garden seeds for per cent of germination before planting.

Bring in your daffodil and jonquil bulbs. If you bring in tulip, hyacinth, or crocus bulbs, keep them cool until they show green shoots.

Complete your garden plans.

Again visit the commercial greenhouse, this time to see preparations for Easter flowers.

ANIMALS.—Remember the birds. Be sure there is food for them, especially if you live where winters are cold and the land covered with snow. A bayberry bush supplies food for birds. Can you find one where you live?

Make a record of your winter residents.

Plan now to build nest boxes for birds. Have someone write to the Superintendent of Documents, Washington 25, D. C. for No. I1.72: 14, *Homes for Birds* (10¢).

Make plans to build bird baths as soon as the weather permits.

Make a census of all the pets owned by members of your class Then each pupil should make a special study of his own pet, or someone else's pet if he hasn't one of his own. Study what foods the pet needs, how much it requires, how often it should be fed, how much water it needs, its vitamin requirement, and about its bed Be sure your pet receives scientific care

SPECIAL ITEM —Make a study of the principal power used in your community or near-by city. Is it water, steam, or electric power? How is it produced, distributed, used?

March Observations

STARS —Are the days getting longer? Note the position of the sunset on the horizon on March 21 or 22 and compare this with its position on December 21 or 22. Try to measure the angle between the two positions What has really happened since December 21–22?

How have the positions of some of the constellations changed since December when observed at the same time of night? Try to explain the changes Remember stars rise about four minutes earlier each night

How many stars can you recognize in the sky and name?

PLANETS —Continue your observation of the planets Learn all about the ones that are visible If you can do so, you will be interested to look at a planet through a telescope

If you started to make a telescope, how is it coming along?

WEATHER —"If March comes in like a lamb, it will go out like a lion" Check this statement to find out if it is true.

Keep a record of March weather, especially wind direction and velocity. Is it true that March is an especially windy month? Compare with data for other months and get official data from the Weather Bureau

PLANTS —If you live in the northern part of the United States, you may wish to start more seeds in boxes indoors Boys and girls in the south, of course, can safely plant seeds out of doors Write for No A1 9.1743/2-3, *Hotbeds and Cold Frames*, (Superintendent of Documents, 10¢)

Pussy willows are beginning to blossom at about latitude 40° N Bring in branches of forsythia to force the yellow blossoms to come out early.

On your garden plans, have you indicated second and third plantings of peas, beans, sweet corn, etc.? Why do you do this?

Remember to run the rows across the slopes and around the hills, not up and down the hillsides. This will help to conserve both soil and water.

In the north the pruning of fruit trees should be completed very soon before the sap begins to run.

Many states observe Arbor Day in April. When does your state observe it? Plan for it now.

Write for A1.9:1987, *Common Diseases of Important Shade Trees,* (Superintendent of Documents, 15¢).

ANIMALS.—Are your bird houses ready? They should be put out now at the latest in most states, except those farthest north.

Robins and bluebirds are finding their way north again. Watch for their migrations.

Keep a bird list all this month and during April and May. List the birds that pass through your country and those that stay with you for the summer.

Prepare to observe Bird Day. This will be a good project for your Bird Club to plan and direct. The following bulletin from the Fish and Wildlife Service, Department of Interior, will help:

CB12, *Improving Farm Environment for Wild Life.*

Write to Biological Survey, Department of Agriculture, for copy of laws relating to bird migration.

Begin again your war on harmful insects. *Swat the fly.* Why? Write to the Superintendent of Documents for the following bulletins: 182L, *Housefly Control;* 145L, *Clothes Moths;* 186L, *Domestic Mosquito* (Department of Agriculture).

Oil on the surface of stagnant water pools will reduce the number of mosquitoes.

Remember cats are natural enemies of birds. Prevent your pets from killing birds, and take stray cats to the Animal Rescue League or Humane Society.

If you live on a farm, look for woodchuck holes. If in a field, they may cause a horse to break a leg. Kill the woodchuck and fill the hole.

Another animal to keep account of is the common meadow mole.

SPECIAL ITEM.—Science and Engineering Fair. Have your club members completed their exhibits for the Science and Engineering Fair? Be sure your exhibit is neatly arranged and labeled, and as perfect mechanically as you can make it. No exhibit is too simple to be worth entering in the Fair.

WATER STORAGE.—Spring is the time of floods. Now is a good time for your class to make a special investigation of floods in your locality What damage usually results? What steps are being taken to prevent flood damage?

In connection with your study, look up one of the great flood control projects and find out what was done and how worth while it is.

Now is a good time to plan your soil conservation projects.

April Observations

STARS.—Keep a record this month of time of sunrise and sunset. Compare with previous records.

Determine the differences in the sunlight and in the shadow, other things being the same. Explain any differences you discover.

PLANETS.—What planet is brightest now? Where is it located among the stars? Is it a "morning" or an "evening" star?

WEATHER.—"April showers bring May flowers." How accurate is this statement? Why?

Observe and record wind directions and velocity, temperatures, kind of precipitation, and kinds of clouds. Keep trying your hand at weather forecasting Watch out for the "cold bug."

What weather factors are related to spring floods? What can be done about it? Write for Miscellaneous Publication 596, U S Department of Agriculture. Write also to your State Conservation Commission. All out for conservation.

PLANTS.—Observe the buds of trees and shrubs Are they showing signs of opening? Are they located at the ends of twigs or along the sides? What difference does their location make in pruning?

In the latitude of New York, red maples and shad bush are in bloom What are the early spring blossoms where you live?

Remember to do all that you can to protect the wild flowers.

Outdoor planting can begin for some seeds even in the north.

Harden up seedlings by exposing them to cool air for gradually increasing periods before transplanting them out of doors.

Clean up around the stems of trees and shrubs Even in the north such seeds as asters, calendulas, cosmos, snapdragons, verbenas, and zinnias can be started safely out of doors.

As soon as you can get at your spring garden work, pull or dig up all weeds. That will save work later on.

Write for No A1.9 2007, *Mixing Fertilizers on the Farm*, (Superintendent of Documents, 5¢), and IS–18, *How Much Fertilizer Shall I Use?* (Department of Agriculture).

Look for early wild flowers, but do not pick them. Many localities where wild flowers grew are no longer suitable for wild things because of storage dams, draining swamps, and clearing woods for crops and buildings. Therefore wild flowers are precious. Learn how to protect those you have. If there are laws to protect wild flowers in your state, learn them and do what you can to have them obeyed.

Organize a Wild Flower Protective Club. If there is an adult nature club or garden club where you live, ask its members to help you. If there is none, perhaps your teacher and parents will want to organize for conservation of the wild plants.

Do something to observe Arbor Day. Plant a tree, plant a shrub, or take steps to protect plants you have against damage. Send to Department of Agriculture for F1567, *Propagation of Trees and Shrubs.*

Make a record of the dates when different kinds of trees and shrubs blossom. Do the leaves or blossoms appear first? If you have cold frames or hot beds, remember to ventilate and water them.

Send to the Department of Agriculture for No. 161L. *Eastern Tent Caterpillars*, if your trees are likely to be troubled with this insect.

ANIMALS.—Spring migration of birds has started, so start your bird lists.

When migration is under way, nesting time for some birds is near. Do they need nesting material and nest boxes where you live? If so, your Chief Bird Observer should be on the alert. Be prepared for your bird guests.

Are your trees likely to be harmed by white marked tussock moths? You can help protect your trees by tying cotton gunny sacks or sticky flypaper around the stem.

Your trees may need to be sprayed to protect them against insects and disease. Be sure to get the advice of tree experts.

Remember to kill every fly you can, and so help to prevent the spread of certain diseases. What diseases do scientists tell us are spread by flies? Mosquitoes? Plan to control mosquito breeding places.

See *DDT for Control of Household Pests* (A77.302: D33/5, Superintendent of Documents, 5¢).

This month has Be Kind to Animals Week. Why not be kind to animals all the time? If you observe cases of cruelty to animals, report them or try to prevent them.

SPECIAL ITEMS.—Make a study of some local industry. Are its processes mainly physical, chemical, or biological? In how many ways is the industry important to you? How does it affect the wild life in your community?

May Observations

STARS.—What constellations are visible these nights that were not visible during the winter? Can you account for the changes?

PLANETS.—Do the planets or the moon have anything to do with the time for planting? What evidence can you give to help prove your ideas?

WEATHER.—Have the planets or the moon any effect on the weather? What evidence can you give to help prove your ideas?

What weather factors do you need to observe to forecast the weather? What instruments are needed?

Continue your weather records and your forecasting. Compare the weather with your forecasts and with official forecasts to test their accuracy.

PLANTS.—Care for your garden. It will be interesting for you to keep an account of the cost of seeds, and the value of your garden products. Is a garden worth while? Consider not only the value of the vegetables and flowers, but also the value of the exercise to your health and the satisfaction you get from the accomplishment.

If you have a camera in which you can use color film, try your skill at photographing flowers. Be sure to make a note of the name of each flower and the date. Try to show leaves as well as flowers.

Make a collection of different kinds of woods. If possible, cut out a piece that will include the bark. If you start with green wood, it must be dried out very slowly. When the piece is dry, sandpaper and polish the surface so the grain will show. If you have a magnifier, examine a cross section, and make a drawing to show what it is like.

ANIMALS.—Baby-bird time is here in many localities. Watch the cats.

Plan early bird hikes. Learn to know the birds by their "calls" and songs as well as by their looks. If you have patience and proper camera equipment, try to photograph the birds.

Have you insect enemies in your garden? If so, write to the U. S. Department of Agriculture for help. The following bulletins are useful: 2L, *Cutworms in the Garden*; 626M, *Handbook on Insect Enemies of Flowers and Shrubs* (35¢). See also *A Vegetable Gardener's Handbook on Insects and Diseases* (Superintendent of Documents, 15¢).

Earthworms are garden helpers. Observe the earthworm to learn its habits and how it is helpful.

SPECIAL ITEM.—What kind of transportation is most important to your community? Make a study of it and its importance. What scientific principles are especially related to it? Try to make a model of some kind to illustrate important things about the industry.

June Observations

Are you busy at this time reviewing the year's school work, taking examinations, going to school picnics, and generally rounding out another successful school year? As you look back over the year's work in science, what important things stand out? How has science helped you?

Let us now plan our science adventures for the summer so that everyone may have interesting experiences and interesting treasures of science to exhibit when school opens again in September.

What to Do in the Summer

Many of you will have jobs of one kind or another to earn money or to get experience. Your work may be caring for city lawns and gardens, or helping a farmer with his work. Perhaps you will take an auto trip to our parks or spend time in a summer camp. Whatever you do or wherever you are, you will have the great outdoors with all its treasures on land, in the water and soil, and in the air. Use every opportunity to know something better than before through your own effort.

Summer adventures will be much more valuable and interesting if you carry a pocket notebook with you for immediate records of what you observe or experience. Whenever you collect a specimen, no matter what it is, always make a note telling exactly when and where you found it and any interesting things about it that you can discover at the time. All specimens collected should be accurately identified and labeled.

Summer clubs might be formed, such as the "Fruit Tree Club," the "Broad Leaf Club," or the "Evergreen Club." Each club would study the particular trees or shrubs represented by its name. The members would learn the shape of the leaf, the bark, the way the tree branches, and other facts about each tree or shrub. All leaves collected should be mounted and labeled. With an ink pad and a roller you can make ink prints of leaves in your books.

Other clubs might be the "Garden Club," the "Vegetable Club," the "Flower Club," or the "Weed Collectors' Club." In these clubs samples of plants, flowers, and even seeds might be collected and visits made to different gardens. Garden insects, butterflies, and moths also present interesting opportunities for adventure in the summer

The "Mineral Collectors' Club" represents a hobby that a great many people enjoy The *Boy Scout Book on Minerals* or books from the public library will help you to identify minerals. Be sure to label each one as you find it, telling where you found it, and all about it Many minerals occur as little crystals in rocks such as limestone. Watch for such crystals as well as for larger samples.

A "Bird Club," like all science clubs, is most successful if its work continues all through the year. Summer records, of course, should continue to give the name of the bird, the date and place seen, what the bird was doing, its song, and any special information.

Finally, a "Science Readers' Club" is suggested Perhaps we should think of this as a "Rainy Day Club," because it is on rainy days that you may feel inclined to go to the library to read about science things you have seen or collected. Rainy days are good days for putting your records and collections in order.

Appendix

Table of Relative Humidity in Per Cent

Locate the dry-bulb temperature in the column at the left marked *t*, and opposite this, in the column headed by the number of degrees difference in temperature between your wet- and dry-bulb readings, you will find the number of per cent of humidity.

t	Difference between the Dry- and Wet-Bulb Thermometers																
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	
55	94	88	82	76	70	65	59	54	49	43	39	34	29	24	19	15	55
56	94	88	82	77	71	65	60	55	50	44	40	35	30	25	21	16	56
57	94	88	83	77	71	66	61	55	50	45	40	36	32	27	22	18	57
58	94	89	83	78	72	67	61	56	51	46	42	37	33	28	24	19	58
59	94	89	83	78	72	67	62	57	52	47	43	38	34	29	25	21	59
60	94	89	84	78	73	68	63	58	53	48	44	39	34	30	26	22	60
61	94	89	84	78	73	68	63	58	54	49	44	40	35	32	27	23	61
62	95	89	84	79	74	69	64	59	54	50	45	41	37	32	28	24	62
63	95	89	84	79	74	69	64	60	55	51	46	42	38	33	29	26	63
64	95	90	85	79	74	70	65	60	56	51	47	43	38	34	30	27	64
65	95	90	85	80	75	70	65	61	56	52	48	44	39	35	31	28	65
66	95	90	85	80	75	71	66	61	57	53	49	45	40	36	32	29	66
67	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	30	67
68	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	31	68
69	95	90	86	81	76	72	67	63	59	55	51	47	43	39	35	32	69
70	95	90	86	81	77	72	68	64	60	55	52	48	44	40	36	33	70
71	95	91	86	81	77	72	68	64	60	56	52	48	45	41	37	34	71
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	35	72
73	95	91	86	82	78	73	69	65	61	57	53	50	46	42	39	35	73
74	95	91	86	82	78	74	70	66	62	58	54	50	47	43	40	36	74
75	95	91	87	82	78	74	70	66	62	58	55	51	47	44	40	37	75
76	95	91	87	82	78	74	70	66	63	59	55	52	48	45	41	38	76
77	95	91	87	83	78	74	71	67	63	59	56	52	49	45	42	39	77
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	42	39	78
79	96	91	87	83	79	75	71	68	64	60	57	53	50	47	43	40	79

Nutrient Solution for Plant Growth

The following solution contains the necessary minerals for plant growth For testing, make three solutions as follows:

1 Containing all minerals
2 Containing all minerals except potassium nitrate
3 Containing all minerals except calcium sulfate Compare growth of seedlings in each of the three solutions and in distilled water.

Water (distilled)	2 quarts
Sodium chloride (table salt)	$\frac{1}{32}$ oz
Calcium sulfate	$\frac{1}{32}$ oz.
Magnesium sulfate	$\frac{1}{32}$ oz.
Calcium phosphate	$\frac{1}{32}$ oz
Potassium nitrate (saltpeter)	$\frac{1}{16}$ oz.

Add one drop of a dilute solution of iron chloride.

See also references for "Soilless gardening" and use of hormones and vitamins for stimulating plant growth

Comparison of Boiling Points of Water, Atmospheric Pressure, and Altitude

(Taylor Instrument Co calculations)

Boiling Points of Water	Barometer Readings Inches of Mercury	Approximate Altitudes in Feet
200° F.	23 45	6650
201° F	23 94	6070
202° F.	24 44	5510
203° F.	24 95	4950
204° F.	25 46	4390
205° F.	25 99	3830
206° F.	26 52	3280
207° F.	27.06	2730
208° F.	27.62	2170
209° F.	28 18	1620
210° F.	28.75	1080
211° F	29 33	530
212° F.	29 92	Sea Level 0
213° F.	30.52	—550

Millibars and Inches of Air Pressure

(U.S. Department of Agriculture, Weather Bureau calculations)

Mb.	Inches	Mb.	Inches	Mb.	Inches	Mb.	Inches	Mb.	Inches	Mb.	Inches
940	27.76	960	28.35	980	28.94	1000	29.53	1020	30.12	1040	30.71
941	27.79	961	28.38	981	28.97	1001	29.56	1021	30.15	1041	30.74
942	27.82	962	28.41	982	29.00	1002	29.59	1022	30.18	1042	30.77
943	27.85	963	28.44	983	29.03	1003	29.62	1023	30.21	1043	30.80
944	27.88	964	28.47	984	29.06	1004	29.65	1024	30.24	1044	30.83
945	27.91	965	28.50	985	29.09	1005	29.68	1025	30.27	1045	30.86
946	27.94	966	28.53	986	29.12	1006	29.71	1026	30.30	1046	30.89
947	27.96	967	28.56	987	29.15	1007	29.74	1027	30.33	1047	30.92
948	27.99	968	28.58	988	29.18	1008	29.77	1028	30.36	1048	30.95
949	28.02	969	28.61	989	29.21	1009	29.80	1029	30.39	1049	30.98
950	28.05	970	28.64	990	29.23	1010	29.83	1030	30.42	1050	31.01
951	28.08	971	28.67	991	29.26	1011	29.85	1031	30.45	1051	31.04
952	28.11	972	28.70	992	29.29	1012	29.88	1032	30.47	1052	31.07
953	28.14	973	28.73	993	29.32	1013	29.91	1033	30.50	1053	31.10
954	28.17	974	28.76	994	29.35	1014	29.94	1034	30.53	1054	31.12
955	28.20	975	28.79	995	29.38	1015	29.97	1035	30.56	1055	31.15
956	28.23	976	28.82	996	29.41	1016	30.00	1036	30.59	1056	31.18
957	28.26	977	28.85	997	29.44	1017	30.03	1037	30.62	1057	31.21
958	28.29	978	28.88	998	29.47	1018	30.06	1038	30.65	1058	31.24
959	28.32	979	28.91	999	29.50	1019	30.09	1039	30.68	1059	31.27

Table of Melting and Boiling Points

(Approximate)

Substance	Melting Point	Boiling Point
Alcohol (ethyl)	– 179° F.	172° F.
Butter fat	100°–107° F.	
Carbon tetrachloride	– 10° F.	214° F.
Crisco	71°–87° F.	
Lard	104°–116° F.	
Paraffin	122°–131° F.	
Tallow	109°–114° F.	
Gold	1945° F.	4698° F.
Iron	2786° F.	4442° F.
Lead	620° F.	2777° F.
Mercury	– 37° F.	675° F.
Phosphorus (Yellow)	111° F.	554° F.
Sulfur	235° F.	833° F.
Water	32° F.	212° F.

Control of Insect and Fungus Plant Diseases

(For detailed information as to best time to spray or dust, and which preparations to use, write to your State Experimental Station. See also MP 605, *A Vegetable Gardener's Handbook on Insects and Diseases* (Department of Agriculture, Washington 25, D.C.)

Insect Control

Calcium arsenate spray:	calcium arsenate	5 tablespoons
	hydrated lime	3 ounces
	water	1 gallon

Use for cabbage caterpillars (before cabbage heads form).

Nicotine sulfate spray:	Nicotine sulfate (40%)	1 tablespoon
	soap	2 tablespoons of flakes
	water	1 gallon

Use for aphids.

Rotenone spray:	cube root powder	3 tablespoons
	water	1 gallon

Use for Mexican bean beetle, spotted cucumber beetle.

Cryolite dust	cryolite	2 pounds
	talc	1 pound
	(Do not add lime or bordeaux mixture)	

Use for cabbage caterpillars (before heads form), melon worm (before fruits form), potato beetle, flea beetles, tomato fruitworm

Nicotine sulfate dust:	nicotine sulfate (40%)	5 teaspoons
	hydrated lime	1 pound

Use for aphids.

Rotenone dust: Dust mixture sold by dealer.

Use for Mexican bean beetle, spotted cucumber beetle, melon worms (after fruit is formed), measuring worms, European corn borer.

Pyrethrum dust: Dust mixture sold by dealer.

Use for measuring worms, pea weevil.

Control of Fungus Diseases

Bordeaux Mixture is used to control Early Blight and Late Blight of potatoes, Celery Blight, and Tomato Leaf Spot It will also control Cherry Leaf Spot, and such diseases as Black Spot on roses For some plants with tender foliage, such as peaches and Japanese plum, sulfur should be used instead of Bordeaux Mixture.

Note.—Bordeaux Mixture may be used as a spray or a dust. Spray should be directed so as to reach the underside of leaves. It is important to use proper quantities for various plants. Be sure to follow directions on the container.

Sulfur is used to control such diseases as apple scab and brown rot on peaches, plums, and cherries. It is often used as a spray in combination with arsenate of lead. Sulfur should not be used on squashes, melons, or cucumbers.

Bordeaux mixture for spraying:

copper sulfate (bluestone)	4 ounces
hydrated lime	4 ounces
water	3 gallons

Dissolve the copper sulfate in half the water first. Make a paste of the lime in a small amount of water. Then add the rest of the water to the paste. Pour the solutions together and mix. Never mix in metal containers. Make a fresh solution each time used. Wash sprayer thoroughly after use.

Some Rules for Weather Forecasting

1. The storm areas (cycles) move across the United States from west to east. They usually pass over the St. Lawrence River region. Or the path goes from the southwest to the northeast and out the St. Lawrence River region. (See map on page 101.)

2. On a weather map, the direction of the wind in the storm area (low) is somewhat circular and opposite to the motion of the hands of a clock. The general direction is along the isobars, crossing them slightly toward the center.

3. Facing the wind, the right hand stretched out at the side will indicate roughly the direction of the storm center.

4. The direction of the wind, together with the position of the storm center, will determine in which of the four quadrants (quarters) of the cyclone the observer is located. The weather conditions of each of the four quadrants of a storm area are somewhat constant.

5. The barometer reading will indicate the nearness or remoteness of the storm center, if the observer refers to the isobars on the weather map.

6. A changing air pressure indicates the approach or passing of a storm area. For example, if your town happens to be in the southeast quarter and the storm is moving so as to bring the northwest quarter to you (draw this on your paper), you can predict weather conditions similar to those prevailing in the northwest quarter. If the storm center has not reached you, you should be able to predict whether the storm center will pass north or south of you and hence what weather you will have. If you know by study of the map how fast the storm is moving, you can predict when it will reach you.

7 A very slowly falling pressure indicates warmer temperatures. A very slowly rising pressure indicates cooler temperatures

8 Generally, winds from the east quadrants with falling barometer indicate stormy weather. Winds changing to the west quadrants indicate fair weather

9 Weather map pressures are sea-level pressures, therefore the barometer reading of a given locality should be converted to sea-level reading to compare with the weather map data Since the pressure decreases as the altitude increases, something must be added to convert a local pressure to sea-level pressure Practically 1 inch should be added for each 900 feet altitude or fraction or multiple thereof. A change of 900 feet in altitude would be equal to about 34 millibars

The Morse Code

A	·–	J	–·–·	S	···
B	–···	K	–·–	T	–
C	· ·	L	—	U	··–
D	–··	M	––	V	···–
E	·	N	–·	W	·––
F	·–·	O	· ·	X	·–··
G	––·	P	·····	Y	·· ··
H	····	Q	··–·	Z	··· ·
I	··	R	· ··		
1	·––·	4	····–	8	–····
2	··–··	5	–––	9	–··–
3	···–·	6	······	0	—
		7	––··		

Glossary

acid—A substance which has a sour taste and turns blue litmus red.

ACTH—A fluid produced by a gland at the base of the brain; has been used successfully in the treatment of severe burns and in diseases of the joints.

adaptation—Fitness to live in a particular place or to do a certain thing.

aëration—The process of putting air into water or soil.

air mass—A volume of air extending many miles over the earth's surface and up to several thousand feet in height. It is made up of air of approximately the same temperature, pressure, and moisture content. It moves as a unit.

air pressure (*atmospheric*)—The pressure exerted by air against objects due to its weight.

alcohol (*grain*)—A liquid having narcotic properties. It is used in some thermometers, and as a solvent.

algae—Simple forms of plant life sometimes found in water.

alkali—A substance which has a slippery feeling and a bitter taste, and turns red litmus blue.

altitude—Distance above sea level; in astronomy, the angular distance of a star above the horizon.

ammonia (*household*)—A solution of ammonium hydroxide in water.

anemometer—An instrument used to measure the speed of the wind.

annuals—Plants that complete their life cycle of growth, reproduction, and death within a single year or season.

anther—Small knob at end of stamen of flower. Inside anther are the pollen grains.

anticyclone—As seen from above in the northern hemisphere, a clockwise-whirling mass of air of high pressure.

area of high pressure—An anticyclone area.

area of low pressure—The center portion of a cyclonic storm.

armature—A coil of wire wound around a soft iron core.

atmosphere—The gases surrounding the earth.

atmospheric pressure—Air pressure: 14.7 lbs. to the square inch at sea level.

atomic energy (more correctly called *nuclear energy*)—A form of energy released when the nuclei of certain elements split.

axis—A line about which a body turns.

bacteria—One-celled, non-green plants invisible to naked eye.

balance—An instrument for accurate weighing.

barometer—An instrument which measures changes in atmospheric pressure.
aneroid—A barometer without liquid.
mercurial—A barometer in which mercury is used

beetles—Insects having armor-like wing covers

Big Dipper—A portion of the constellation Ursa Major, in the form of a dipper, in the northern sky. It is called Big to distinguish it from a similar but smaller constellation

blue vitriol—Copper sulfate, a solution sometimes used to kill algae in water, and as an ingredient of spray materials for the control of fungus diseases of plants

boiling point—The temperature to which a liquid must be heated to cause it to change rapidly to a gas (This temperature is constant for each pure liquid)

borax—A white alkaline powder often used for softening water

budding—Propagating plants by inserting a bud into the growing part of the stem of another plant.

bulb—A special stem structure in which food is stored by a plant to start the growth the next season.

burdock—A weed

capillarity—The lifting of certain liquids by means of small, tube-like spaces

carbohydrates—Sugar, starch, and cellulose compounds made of carbon, hydrogen, and oxygen

carbon tetrachloride—A non-combustible liquid commonly used for cleaning cloth and putting out fire. It is sold under various trade names.

Cassiopeia—A constellation forming a "W" in the northern sky. In certain positions it appears inverted.

cause and effect—A cause is a happening that always precedes another happening (the effect) and without which the second happening could not occur

caustic soda—Sodium hydroxide; an alkaline substance used in making soap

celestial—Referring to the heavens, the apparent sky sphere.

centigrade—A thermometer scale divided into one hundred divisions between the freezing temperature and the boiling temperature of water.

cesspool—An underground tank with drain, for the disposal of sewage.

chain reaction—A process by which products given off in a change of state cause more of the original material to change.

characteristics—The features which distinguish one substance from another

chemically pure—The condition of a substance when it contains no foreign material.

chloride of lime—A white powder containing chlorine and used both to kill germs and as a deodorizer

chlorination—Putting chlorine into a water supply for the purpose of killing bacteria.

chlorine—A greenish-yellow gas or liquid, sometimes used to destroy germs.

chlorophyll—Green coloring matter of leaves and bark.

chronometer—A ship's clock.

clinical thermometer—A fever thermometer.

cloud—Visible fog mass some distance above earth's surface.

cirrus—A feathery cloud, high above the earth.

cumulus—A cloud having a rounded or dome-shaped top.

nimbostratus—Usual rain clouds. Low-lying stratus clouds heavy with moisture which gives them dark color.

nimbus—A storm cloud.

storm—Rain- or snow-bringing clouds of dark gray aspect.

stratocumulus—Combination cloud, part stratus, part cumulus. Usually formed when cumulus clouds begin to spread out.

thunder—Dark cumulus clouds which give rise to thunder storms.

cocoon—Nest-like case in which larva rests while changing form.

codling moth—An insect whose larva is best known as the "worm" in the apple.

cold front—The advancing boundary of a large mass of cold air.

cold wave—A period of continued cold weather.

compass—A magnetic needle free to swing above a dial with the directions marked on it.

compost—A heap of decomposing (decaying) vegetable matter.

compound—A substance composed of two or more elements chemically combined.

condensation—The process by which a gas is changed to the liquid form.

condenser—A piece of apparatus used to cool a gas and so change it to a liquid.

conduction—The transfer of heat through solids from particle to particle.

conductor (electrical)—A metal rod or wire that transmits electricity efficiently.

conduit—A pipe used to conduct water from its source to a reservoir.

conservation—The careful and scientific method of using and, where possible, replacing natural resources.

constellation—A group (configuration) of prominent stars.

contamination—Making food or water unfit to be taken into the body.

contour planting—A scientific method of tilling the soil whereby rows are planted horizontally around hills rather than up and down.

contract—To draw together; to occupy less space because of cooling.

convection—The transfer of heat by the movement of gases and liquids.

corona—A ring of colored light appearing close around the sun or moon.

cortisone—A chemical produced by the outer layer of the adrenal glands; has been used with dramatic results in treatment of arthritis (a painful stiffening of the joints).

cotyledon—The part of a seed which contains the food needed to start the new plant.

cross-pollination—The transfer of pollen from one flower to the pistil of another.

current electricity—A flow of electrons.

cutting—A part of the stem of a plant which can be made to develop roots.

cutworm—An insect larva which eats stems of young plants.

cyclone—As seen from above in the northern hemisphere, a counter-clockwise-whirling mass of air having a low air pressure at the center.

DDT—A chemical which kills insects on touching their bodies.
decompose—To break up by decay or chemical action.
degree—One three-hundred-sixtieth of a circle; also intensity of heat.
density—The closeness or compactness of the particles composing a substance.
dentine—Bone-like substance of a tooth just inside the enamel
deposit—Sediment
detergent—A soap substitute, contains no soap, but produces more suds in hard water than does soap.
dew—Moisture which collects on the surface of cool bodies.
diameter—The distance through the center of a circle or sphere
dilution—The addition of large quantities of a liquid such as water to a solution to make it more dilute
diphtheria—A contagious bacterial disease attacking the throat, appendix
disinfectant—A chemical substance used to kill germs or to render them harmless
disposal—Getting rid of material such as wastes of various kinds, *e g*, sewage, garbage
dissolve—To cause a substance to be equally distributed throughout a liquid, so that it will not settle out and cannot be separated by filtering, *e g*, oxygen, sugar, or salt dissolved in water.
drainage area—All land drained by a river system.
earth—The third planet from the sun in the solar system
eclipse—The cutting off of the light from a lighted body
electric charge—A quantity of electricity on a body
electricity—A form of energy.
electromagnet—A temporary magnet deriving its magnetism from the flow of electricity through a coil of wire.
electron—A negative charge of electricity
element—A substance which cannot be separated into simpler substances by ordinary chemical means.
ellipse—An oval figure with both ends alike
elliptical—Shaped like an ellipse
emulsion—A liquid mixture containing small fat particles equally distributed throughout
enamel—The hard outer covering of the teeth.
energy—The ability to do work; manifest as heat, light, electricity; atomic, mechanical, and chemical energy
epidermis—The outer layer of the skin.
equator—An imaginary great circle about the earth, midway between the poles
equinox—Time of equal day and night all over the earth
evaporation—To change from liquid to gas The process by which a liquid is changed to a gas
expand—To grow larger in volume or size, to take up more space
Fahrenheit—A thermometer scale divided into 180 divisions between the freezing temperature and boiling temperature of water.

fat—A greasy, easily melted or liquid compound, found in animal and vegetable tissues.

faucet—The part of the plumbing that controls the flow of water from pipes.

fertilization—A part of the reproduction process in many plants and animals. It consists of the union of a sperm nucleus with an egg nucleus.

fertilizer—A substance used to enrich the soil to improve plant growth.

filter—Device for straining out undissolved materials from liquids.

flats—Shallow boxes filled with soil for starting seeds indoors.

fluoride—Poisonous chemical. Combined with certain other chemicals, it forms a compound which seems to help prevent tooth decay.

flushing—Washing out waste by means of a flow of water.

fog—Fine drops of water visible in the atmosphere near the earth.

freeze—To change from a liquid to a solid state.

freezing point—The temperature at which a liquid changes to the solid state.

frost—Frozen water vapor; minute crystals on grass, window panes, and other objects, formed by the freezing of moisture as it is deposited from the air.

fungus—A kind of plant which gets its food from other organic material. Because it contains no chlorophyll, it cannot make its own food as do the green plants.

galaxy—An astronomical system made up of vast numbers of suns.

galvanometer—An instrument used to detect the flow of an electric current.

garbage—Food waste from the kitchen.

gas—A form of matter which has no definite shape and no definite volume; *e.g.*, air, hydrogen.

sewer—Gas arising from the decaying matter in a sewer.

gasoline—An inflammable, volatile liquid used as fuel and as a solvent.

germ—A one-celled plant or animal.

germinate—To start to grow.

gills—Organs needed to enable fish, tadpoles, and similar animals to get oxygen from water.

glands, sweat—Glands in the skin which secrete sweat (perspiration).

glycerine—A by-product of soap making.

grafting—To propagate plants by inserting a piece of the stem of one plant into the growing layer of another plant.

gravitation—The attraction that every body has for every other body in the universe.

gravity, force of—The attraction or pull between the earth and other objects.

gravity pressure—The pressure exerted by any substance due to its weight (or to the force of gravity).

gravity system—A method of obtaining a water supply from a higher source by means of the force of gravity.

grease—Fats and oils.

Greenwich—A borough of London, England; the prime meridian passes through it.

grubs—Larvae of some insects.

hail—Ice globules built up of ice layers deposited on a frozen raindrop
halo—A ring of light similar to a corona but appearing farther away from the sun or moon
hardness, permanent—Hardness of water due to the presence of dissolved minerals that cannot be removed by boiling.
hardness, temporary—Hardness of water due to the presence of dissolved minerals that may be removed by boiling
hard water—Contains minerals in solution which combine with soap and retard the formation of suds.
heat capacity—The quantity of heat which a definite quantity of a given substance can absorb before it changes its temperature one degree
hemisphere—Half a sphere.
hibernate—To pass the winter season in a state of sleep or near sleep.
horizon—The line where the sky and earth seem to meet.
hot wave—A period of continuing hot weather.
house fly—The fly most common in and about houses
humidity—The invisible gaseous moisture in the air.
relative—The ratio of the amount of moisture in the air to the amount needed to saturate the air at a given temperature.
hydrogen—The lightest known gas; a combustible gas
hygrometer—An instrument for measuring the relative humidity of the air
ichneumon fly—A useful insect
illuminate—To light up or make visible by reflected light.
impurities—Substances not belonging in (foreign to) the substance where they occur, *e g*, minerals dissolved in water.
insoluble—Impurities which are not dissolved
soluble—Impurities found in a dissolved state
incinerator—A special firebox or oven in which to burn garbage and rubbish
inclination—The tipping of the earth's axis toward the plane of its orbit.
insect—A small animal that lives in various stages and has six legs at the final stage
insect pests—Insects of such habits and occurring in such abundance that they are harmful to man
insoluble—Not capable of being dissolved in a particular liquid (No substance is absolutely insoluble. The terms *soluble* and *insoluble* are relative)
insulate—To prevent the transfer of heat (or electricity).
iron, galvanized—Iron (sheet or wire) coated with zinc.
irrigation—Artificial watering of land by means of ditches, sprinkling pipes, etc
isobar—A line drawn on a weather map through places having the same barometric reading (air pressure) at a given time.
isotherm—A line drawn on a weather map through places having the same thermometer reading (temperature) at a given time.
Jupiter—The fifth and largest planet

lady-bird beetle (sometimes called *lady-bug*)—A useful insect which helps to control the cottony-cushion scale of California.

land breeze—A breeze moving from the land toward the water.

larva—The second stage of development in many insects; *e.g.*, caterpillar, grub, maggot.

latitude—Distance in degrees north or south of the equator.

life history—The history of any organism (living thing) from the beginning to the end of its life.

lightning—A discharge of electricity between two or more clouds or between clouds and objects on the earth.

lightning rod—A metal rod that attracts and conducts to the ground any lightning charges which may strike in the near vicinity of the building to which it is attached.

light year—The distance that light travels in a year (about six trillion miles).

lime—A common name for substances (calcium bicarbonate or calcium sulfate) that cause hardness in water.

liquid—A substance which takes the form of the containing vessel and fills a definite part of it. One of the three states of matter, *e.g.*, water, mercury.

litmus—A chemical substance used for detecting acids and alkalies; it turns red in acid and blue in alkali.

lodestone—A form of iron ore which is magnetic.

longitude—Distance in degrees east or west of the prime meridian.

magnet—A piece of iron that can attract other iron.

magnetic field—The area around a magnet through which magnetic force is acting.

magnitude—In the astronomical sense magnitude means relative brightness of the stars.

Mars—The fourth planet; earth's second nearest planet neighbor.

matter, inorganic—That which has never had life.

matter, organic—That which forms a part of, or has come from, living things.

melting point—The temperature at which a solid changes to the liquid state.

mercury (*quicksilver*)—A heavy, silver-white, liquid metal.

Mercury—The smallest planet and nearest the sun.

meridian—Any great imaginary circle about the earth which passes through both poles.

migrate—To move from one locality or place of living to another.

mildew—A variety of fungus.

Milky Way—A luminous band encircling the heavens, composed of many stars so distant that they are separately invisible to the naked eye. The galaxy to which our solar system belongs.

millibar—A unit of measurement of atmospheric pressure; one inch of mercury equals 34 millibars.

mineral—Inorganic matter of which rocks and soil are composed, usually occurring as crystals.

molar—A tooth adapted for grinding, located at the back of the jaw.

mold (*bread*)—A variety of fungus.

molecule—A very tiny particle of matter.

moon—A satellite of the earth.

mulching—Covering surface soil with a layer of dust, humus, dead leaves, straw or paper, in order to break up capillary spaces or to protect plant roots

Neptune—The planet second farthest from the sun; not visible to the naked eye

nitrify—To produce nitrogen compounds as in the case of certain bacteria on plants

node—The part of a stem from which a bud grows

non-conductor—A substance that prevents to a considerable extent the transfer of heat (or electricity).

noon—The exact time at which the sun passes across the zenith meridian of a given place.

North Star (pole star)—The star toward which the north end of the axis of the earth points.

nucleus—The center of development of a cell; the central, heavy part of an atom.

oil—A liquid fat usually of vegetable origin.

oil, kerosene—An inflammable liquid sometimes used as fuel, obtained from petroleum by distillation

orbit—The path of a planet or other body around the sun or other heavenly body.

organism—Any living thing

Orion—A constellation

osmosis—The process by which liquids or gases pass through a membrane and become mixed

ovary—The seed case of a flower.

oxidize—To combine with oxygen as in burning, rusting, decaying

oxygen—The active gas which makes up about 21% by volume of the air.

parallels—Imaginary circles about the earth running east and west, parallel with the earth's equator.

parasite—An organism which get its food from other living things, living within or upon it

pasteurize—To heat a food (milk) to 145° F. for thirty minutes to destroy bacteria

penicillin—One of several antibiotics, a drug obtained from mold which grows in the ground, controls many diseases

perennials—Plants that form flowers and seeds year after year.

perspiration (sweat)—Water, containing other substances, given out by sweat glands.

phases of the moon—The different forms that the lighted half of the moon appears to have during each month

photoelectric cell—A device which produces an electric current when light falls upon it

pistil—The part of a flower which receives the pollen.

plane—A level surface.

planet—A heavenly body shining by reflected light and revolving about the sun.

plumbing—The pipes, traps, etc., which carry fresh water into a house and waste water out.

Pluto—Farthest known planet from the sun.

Pointers—Two stars of the Big Dipper that are in line with the North Star.

Polar Front Theory—A theory which explains how cyclones are formed where masses of cold air and warm air meet.

polar regions—Regions near the north pole and the south pole.

pollen—Cells formed in the anthers of flowers and necessary for fertilization.

polluted—Made impure; capable of producing sickness.

precipitation—Moisture falling from the clouds or separating from the air; *e.g.*, rain, snow, sleet, hail, fog, frost, dew; or solids separating from solution.

predict—To foretell; to tell what is likely to happen.

preservative—A substance added in small quantities to food to keep it from spoiling for a time.

pressure (air)—See *atmospheric pressure.*

prime meridian—The meridian which passes through Greenwich.

propagation—Producing new plants or animals.

property—A characteristic of a substance which helps one to recognize it.

pumping system—The method of obtaining a water supply from a source by means of force pumps.

pupa—The resting stage of an insect before it becomes an adult.

pure—Containing no foreign or other material.

radar—An electronic device which locates the distance and direction of objects by means of certain types of radio waves.

radiant—Energy as heat or light, given off in all directions from a highly heated body.

radiation—Sending out energy in all directions from a body.

rain—Drops of water falling from clouds.

rainbow—An arch of light, showing the colors of the spectrum.

rain gauge—An instrument to measure the amount of rainfall or snowfall.

rainmaking—A process of seeding clouds with small particles of dry ice or other chemicals to produce rainfall.

rays—Imaginary lines representing the direction or motion of energy (heat or light).

reduce—To separate certain parts of a compound in order to obtain some desired product; *e.g.*, fertilizer from garbage by removal of fats.

reflect—To turn something back, as a body turns back, reflects, light or heat directed against it.

reproduction—The process by which plants and animals produce offspring.

reservoir—A large tank or basin where water or other material is stored.

revolution—The movement of a body in its orbit traveling around another body.

rotation—The turning of the earth or some other body on its axis.

sanitation—The scientific control of conditions required to produce healthful surroundings

saturated—The condition of a substance when it can hold or absorb no more of another substance; *e g*, a sponge filled with water; air filled with moisture

Saturn—The sixth planet, the planet with rings

sea breeze—A breeze moving from the sea towards the land.

season—A division of the year, as determined by the earth's position with respect to the sun.

seed—A ripened ovule which will produce a new plant if placed under suitable conditions

septic tank—A tank containing sewage in which bacteria are allowed to decompose the organic matter.

sequence—Events or happenings following one another in a regular order, as cause and effect

serum—A preparation which counteracts the effects of poisons produced by disease germs, is immediate in its action; does not produce immunity

sewage—Water containing wastes from the body

sextant—An instrument used to determine the altitude of the sun at exact noon

sleet—Very small, frozen raindrops.

sludge—Sediment from sewage

snow—Ice crystals formed from frozen water vapor

soap—A chemical compound made from an alkali and a fat.

sodium hydroxide—See *caustic soda*

solar system—The sun and the planets as well as about one thousand smaller, invisible bodies

solar time—Time measured by reference to the sun.

solid—A form of matter that holds its shape under ordinary conditions

soluble—Capable of being dissolved in water or other liquids.

solute—A dissolved substance

solution—A clear even mixture of a soluble substance and its solvent. (See *dissolve*.)

solvent—A liquid or gas which is able to dissolve another substance, *e g*, alcohol is a solvent

sounder—The part of a telegraph instrument which produces the sounds of the code.

sperm cell—Male reproduction cell

sphere—A solid object on whose surface all points are at equal distance from the center.

spring—The season between winter and summer; underground water appearing in a stream at the surface

stars—Other suns like ours generating (producing) their own light.

static electricity—Electricity that remains on an object; stationary electricity.

storm—An atmospheric disturbance, usually accompanied by rain, or snow, or hail, and wind.

storm area—Cyclone area—a "low."

storm paths—The route followed by a storm area, cyclone.

strip planting—A scientific method of tilling the soil whereby strips of soil-binding crops are planted alongside crops which have little ability to hold soil.

sucking insects—A class of insects whose mouth parts are adapted for sucking liquids from plants or animals.

sulfa drugs—A large group of drugs, all of which contain sulfur; valuable for certain types of infections.

suns—Stars.

sun spot—A dark area appearing on the surface of the sun; believed to be storms in the sun's atmosphere.

superstition—Belief based on supernatural explanations, or coincident relations instead of scientific cause and effect.

taconite—A plentiful ore containing about 25% iron; can now be used as a source of iron.

telegraph—An instrument for sending messages by means of code. The sending key controls the flow of electricity through the wires. The electric current operates the sounder.

telephoto (*telephotography*)—A process of reproducing photographs by means of electrical impulses.

telescope—An instrument for magnifying distant objects such as ships at sea, or stars.

teletype—the teletypewriter; an application of telegraphy to operate type-writing machines at distant points.

television—An electron system for sending pictures over a distance by means of radio waves.

temperature—The degree of heat of a substance.

thermometer—An instrument to measure the temperature.

thunder—The report following a lightning discharge.

tide—The raising and lowering of ocean water due to the attraction between the earth and the sun and moon.

time, standard—The clock time for a time zone.

time zone—A belt (region) of the earth, running north and south, using the same clock time throughout.

toad—A small animal having a warty skin and living on insects found in gardens and fields.

tornado—A storm with very high wind.

torrid (*tropical*) *zone*—The part of the earth between the tropics of Cancer and Capricorn.

transplanting—Transfer of a plant from one place to another.

trap—A U or S bend in a waste pipe of a plumbing system. It prevents entrance of sewer gases into the room from which the pipe serves as a waste outlet.

turbine—A type of wheel made to spin by the force of expanding gases (such as steam) or by moving water.

twilight—Diffused light between sundown and darkness.

typhoid fever—A contagious disease attacking the digestive system (intestines) It is commonly spread through water or milk, or by the housefly.

universe—The great system of galaxies.

unsanitary—Not healthful.

Uranus—The seventh planet; not visible to the naked eye

vaccine—A preparation containing dead or weakened disease germs; when inoculated into the body, produces immunity to the disease.

velocity—Speed

Venus—The second planet in distance from the sun; the earth's sister planet.

vernal—Belonging to springtime.

volatile—Easily changing to a gas when exposed to the atmosphere.

volume—The size of anything, the space (room) it occupies.

warm front—The advancing boundary of a large mass of warm air.

warts—Small growths formed on and rooted in the skin

washing soda—Sodium carbonate—used to soften water for household and industrial uses.

water—A compound of hydrogen and oxygen

water cycle—The circulation of water in nature through the processes of evaporation, condensation, and precipitation.

water, distilled—Pure water obtained by the process of distillation (evaporation and condensation)

water, hard—Water containing a large amount of dissolved minerals such as sulfates and bicarbonates of calcium and magnesium.

water pressure—The force of water exerted against objects due to its weight, or pressure of water caused by mechanical means.

water, soft—Water containing little hardness-causing minerals.

water table—The level or surface of underground water.

weather—The condition of the atmosphere for any part of the country at a given time.

weather factors—Conditions which make up the weather; *i.e.*, precipitation, temperature, humidity, wind velocity and direction, condition of the sky, and atmospheric pressure.

weather map—A map upon which weather factors at United States Weather Stations are indicated for a given hour of the day.

weather vane—An instrument for indicating the direction from which the wind is blowing

well—A hole dug deep enough to obtain water, oil, or gas.

wind—Air in motion.

zenith—The point in the sky directly overhead

zinc—A bluish-white metal, used to coat iron to prevent rusting.

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